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NATIONAL DAM INSPECTION PROGRAM. UPPER KITTANNING DAM. NDI ID N--ETC(U)
SEP 78 DACW31-78-C-0049

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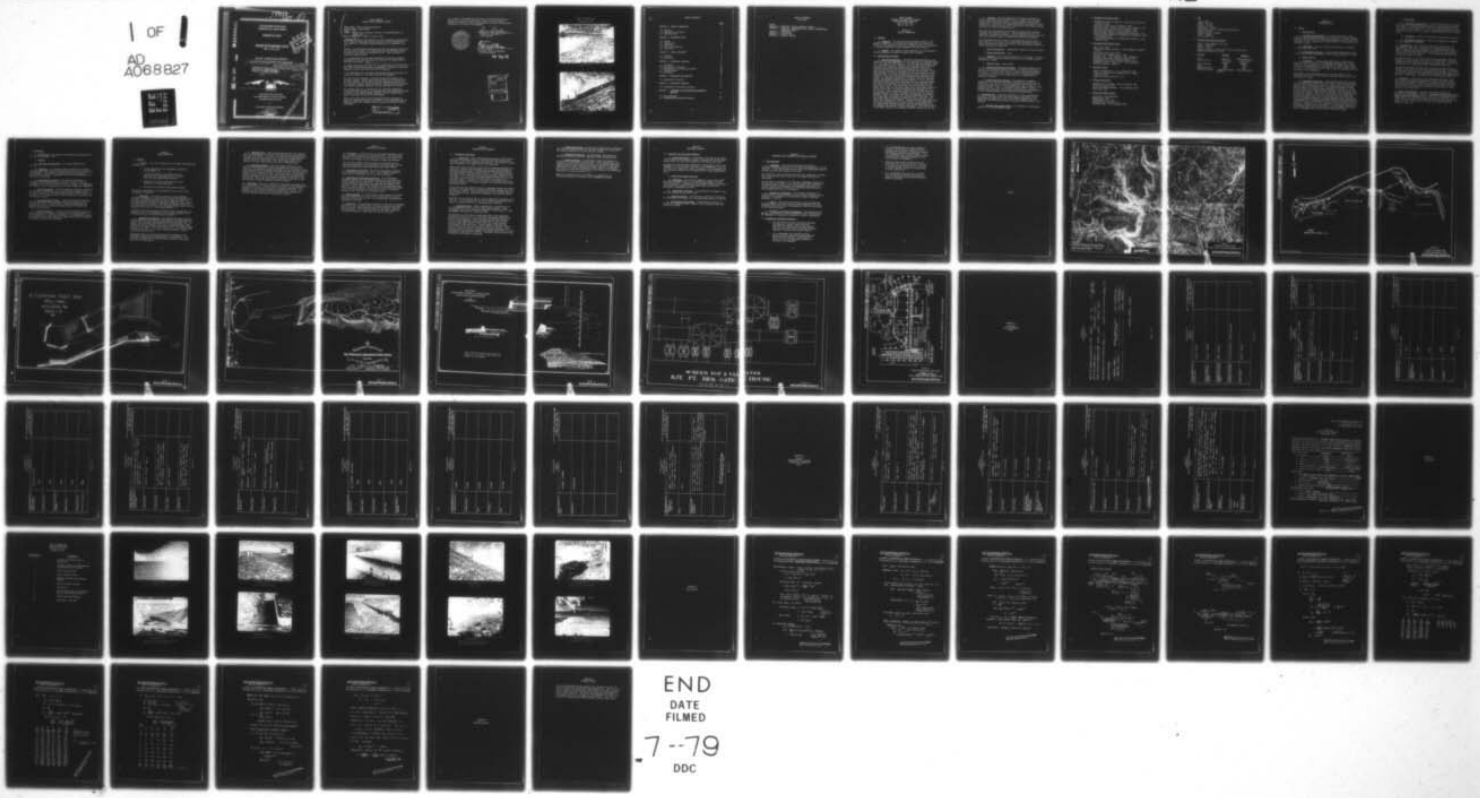

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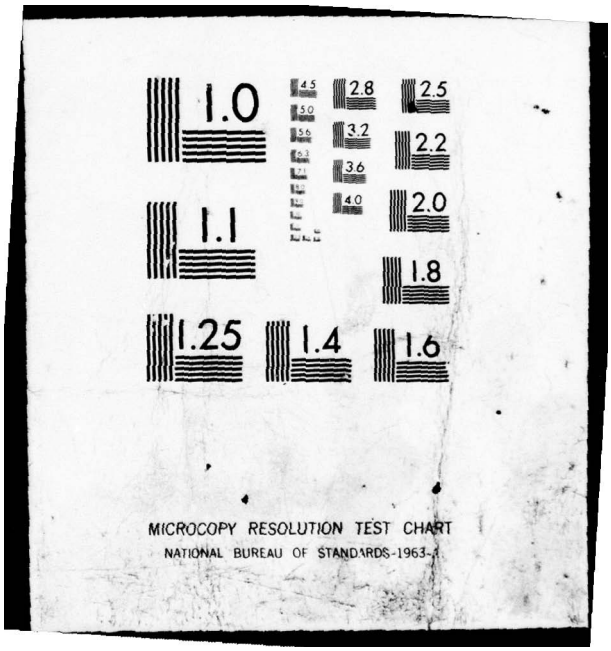
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SUSQUEHANNA RIVER BASIN
BURGOON RUN, BLAIR COUNTY

PENNSYLVANIA

UPPER KITTANNING DAM

NDI I.D. NO: 530

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM.

Upper Kittanning Dam, NDI ID Number 530, Susquehanna River Basin, Burgoon Run, Blair County, Pennsylvania. Phase I. Inspection Program.

Contract No. DACW31-78-C-0049

75 p.

PREPARED FOR

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND 21203

BY

D'APPOLONIA CONSULTING ENGINEERS
10 DUFF ROAD
PITTSBURGH, PA. 15235

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PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM

NAME OF DAM: Upper Kittanning Reservoir
STATE LOCATED: Pennsylvania
COUNTY: Blair
STREAM: Burgoon Run, secondary tributary of Beaverdam Branch of Juniata River
DATE OF INSPECTION: August 8 and 16, 1978

ASSESSMENT: Based on the evaluation of the conditions as they existed on the dates of inspection and as revealed by visual observations, the condition of the Upper Kittanning Reservoir is considered to be fair.

However, city maintenance personnel reported that upstream control for the lake blow-off pipe is not operational and the discharge through this pipe is controlled by downstream valves. Thus, the pipe is constantly under pressure.

It is recommended that the owner immediately perform the necessary maintenance to the upstream controls located at the intake tower to make them operational.

No design information was found for the configuration of the blow-off and supply line located through the embankment. Therefore, structural adequacy of these facilities could not be assessed.

It is recommended that the owner take necessary steps to evaluate the structural integrity of the pipes through the embankment.

The flow from the watershed is diverted around the reservoir by a diversion channel. Normal inflow into the lake can be controlled by an inlet structure, but at 28 percent PMF, uncontrolled inflow into the reservoir through a diversion channel overflow section would equal the combined discharge capacity of the two spillways for the dam.

The spillway capacity is classified to be "seriously inadequate" (28 percent PMF), because it is estimated that overtopping would result in failure of the dam and damage potential would be significantly higher than would exist prior to overtopping.

Since the spillway capacity was determined based on the Corps of Engineers' approximate analysis procedure, it is recommended that the owner reevaluate the spillway capacity using more accurate analysis techniques.

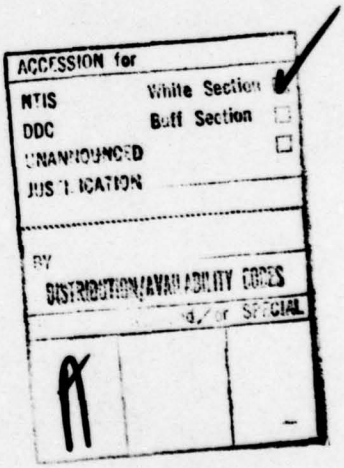
It is further recommended that the owner provide around-the-clock surveillance during unusually heavy runoff to detect possible problems and develop a formal warning system to alert the downstream residents in the event of an emergency.

Lawrence D. Andersen, P.E.
Vice President

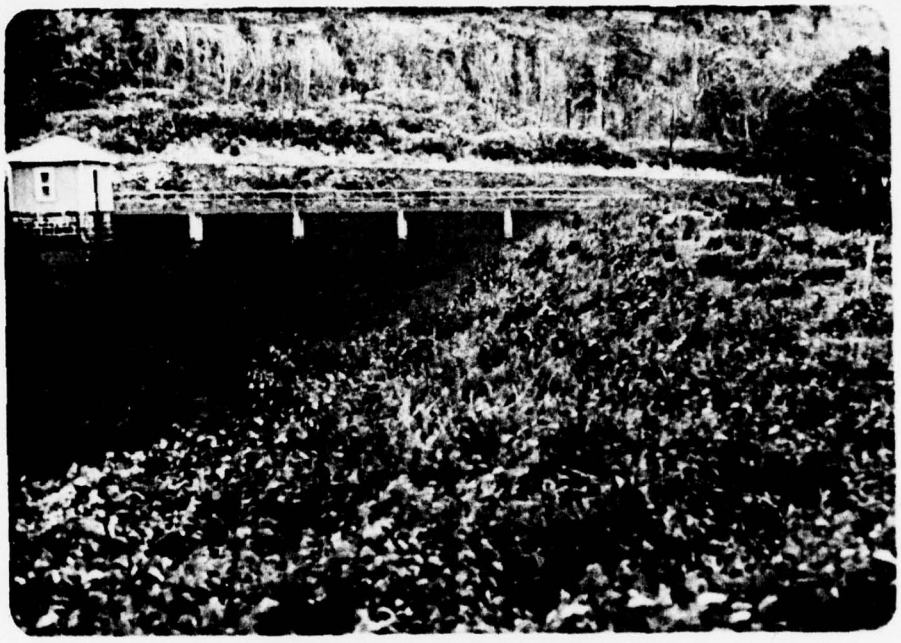
Approved By:

G. K. WITHERS
Colonel, Corps of Engineers
District Engineer

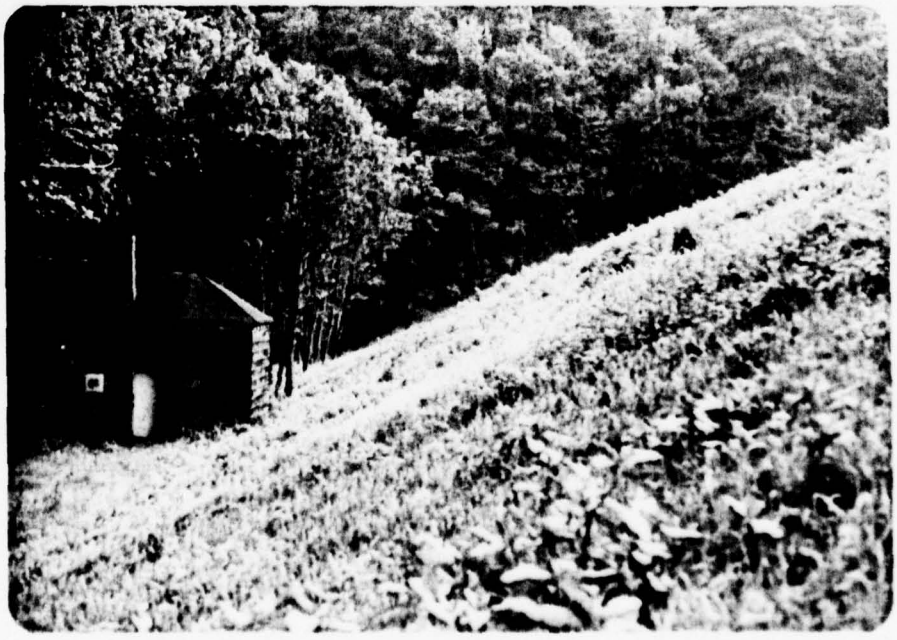
28 Sep 78



UPPER KITTANNING DAM
NDI I.D. NO. 530
AUGUST 8, 1978



Upstream Face



Downstream Face

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PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM
UPPER KITTANNING RESERVOIR
NDI I.D. NO. 530
DER I.D. NO. 7-13

SECTION 1
PROJECT INFORMATION

1.1 General

a. Authority. The inspection was performed pursuant to the authority granted by The National Dam Inspection Act, Public Law 92-367, to the Secretary of the Army, through the Corps of Engineers, to conduct inspections of dams throughout the United States.

b. Purpose. The purpose of this inspection was to determine if the dam constitutes a hazard to human life or property.

1.2 Description of Project

a. Dam and Appurtenances. The Upper Kittanning Reservoir dam consists of an earth embankment 550 feet long and with a maximum height of 45 feet from the downstream toe. The dam forms an offstream reservoir, into which flow is controlled by an upstream intake structure. A 20-foot-wide trapezoidal channel around the left side of the reservoir diverts the flow from the watershed past the reservoir. Flow into the reservoir is discharged through two spillways. On the right abutment, a 34-foot-wide ogee weir at a level about five feet below the crest of the dam constitutes the primary spillway for the reservoir. Flow from this spillway discharges into Lower Dam downstream. The emergency spillway for the dam is located on the dike between the diversion channel and the reservoir. It is a 50-foot-wide broad-crested weir which discharges into the diversion channel. The crest of the emergency spillway is at a level about four feet below the dam crest. The outlet works for the dam consist of an intake tower, blow-off and supply lines, and a valve house located at the toe of the dam. No design information was available for the outlet works. Field observtions indicate that two cast-iron pipes, one approximately 16 inches in diameter and the other 24 inches in diameter, connect the intake tower and the downstream valve house. The 24-inch pipe constitutes the blow-off pipe for the lake. Flow from these pipes is discharged through two 8-inch and four 4-inch pipes, each equipped with a valve. Although the flow from these pipes can also be controlled by the valves located at the intake tower, city maintenance personnel reported that the upstream controls are not normally used and have not been operational. Two 8-inch and four 4-inch pipes constitute the emergency drawdown facility for the dam.

b. Location. Upper Kittanning Dam is located in Burgoon Run Valley, about 2000 feet downstream from the tunnels under the Penn-Central Railroad Horseshoe Curve, in Logan Township, Blair County, Pennsylvania. The dam is the uppermost reservoir in a series of three reservoirs in Burgoon Valley and is located about three miles upstream from the city line of Altoona (Plate 1).

The runoff from the Burgoon Run watershed is diverted by a channel bypassing the reservoir (Plate 2). The controlled inflow into the reservoir is discharged through the primary spillway and flows into the Lower Dam reservoir, which is located about 1000 feet downstream.

It is estimated that the failure of this reservoir during a flood would result in the failure of the downstream reservoirs and the combined discharge would cause large loss of life and property damage in Altoona and further downstream.

c. Size Classification. Intermediate (based on a 45-foot height).

d. Hazard Classifiction. High.

e. Ownership: City of Altoona (address: Mr. William L. Cochran, Director, Water, Parks and Public Property, City of Altoona, Altoona, Pennsylvania 16601).

f. Purpose of Dam. Water supply.

g. Design and Construction History. Available documents do not indicate the construction date of the dam. A spillway plan found in the city records, dated 1887 (Plate 3), shows a proposed enlargement of the dam. A plaque on the wall of the valve house indicates that the valve house was erected in 1888 and Mr. C. W. Knight was the responsible engineer.

h. Normal Operating Procedure. The reservoir is normally maintained at the level of the primary spillway leaving five feet of freeboard to the top of the dam, as measured in this inspection. In a plan dated 1889 (Plate 4, the spillway crest level is shown to be at Elevation 1496.40. The U.S. Geological Survey (USGS) 7.5-minute Hollidaysburg quadrangle (photorevised 1972) shows the pool elevation of Upper Kittanning Dam to be at Elevation 1496 (USGS Datum).

1.3 Pertinent Data. Elevations referred to in this and subsequent sections of the report were calculated based on approximate field measurements assuming the crest of the primary spillway to be at Elevation 1496 (USGS Datum) which is the pool elevation shown on the USGS map.

a. Drainage Area (square miles) - 0.1 (direct); 9.5 (diversion channel); 9.6 (total watershed area)

b. Discharge at Dam Site (cfs)

Maximum known flood at dam site - 3000 (The dam was overtopped in 1894)
Warm water outlet at pool elevation - N/A
Diversion tunnel low pool outlet at pool elevation - N/A
Diversion tunnel outlet at pool elevation - N/A
Gated spillway capacity at pool elevation - N/A
Gated spillway capacity at maximum pool elevation - N/A
Ungated spillway capacity at maximum pool elevation - 1650 at Elevation 1501
Total spillway capacity at maximum pool elevation - 1650 Elevation 1501

c. Elevation (USGS Datum) (feet)

Top of dam - 1501
Maximum pool-design surcharge - 1497 (emergency spillway crest)
Full flood control pool - N/A
Recreation pool (normal pool) - 1496
Spillway crest - 1496 (primary); 1497 (emergency)
Upstream portal invert diversion tunnel - N/A
Downstream portal invert diversion tunnel - N/A
Streambed at center line of dam - 1456 (estimated)
Maximum tailwater - Unknown

d. Reservoir (feet)

Length of maximum pool - 1200 at Elevation 1501
Length of recreation pool (normal pool) - 1200 at Elevation 1496
Length of flood control pool - N/A

e. Storage (acre-feet)

Recreation pool (normal) - 200 at Elevation 1496
Flood control pool - N/A
Design surcharge (maximum) - 212 at Elevation 1497
Top of dam - 263

f. Reservoir Surface (acres)

Top of dam - 12± (estimated)
Maximum pool - N/A
Flood control pool - N/A
Recreation pool (normal) - 12
Spillway crest - 12 at Elevation 1496

g. Dam

Type - Earth
Length - 550 feet
Height - 45 feet
Top width - 15 feet
Side slopes - 2H:1V (upstream and downstream)
Zoning - Unknown
Impervious core - Unknown
Cutoff - Unknown
Grout curtain - No

h. Diversion and Regulating Tunnel

Type - 24-inch-diameter cast iron
Length - 200+ feet
Closure - Valve
Access - Valves at intake tower and at the valve house
Regulating facilities - Valve

i. Spillway

	Primary	Emergency
Type -	Ogee weir	Broad-crested weir
Length of weir -	34 feet (as measured)	50 feet (as measured)
Crest elevation -	1496	1497.2
Gates -	None	None
Upstream channel -	Lake	Lake
Downstream channel -	Rectangular masonry channel	Diversion channel

SECTION 2
ENGINEERING DATA

2.1 Design

a. Data Available

(1) Hydrology and Hydraulics. No original design data were found for the hydrology and hydraulics for the dam. A report prepared by Hazen, Whipple and Fuller Consulting Engineers of New York, New York, dated May 27, 1921, summarizes the design capacity of the spillway and diversion channel.

(2) Embankment. State and owner files included no information on the design of the dam.

(3) Appurtenant Structures. Limited design drawings were found on the 1887 and 1889 modifications of the primary spillway of the dam.

b. Design Features

(1) Embankment. A drawing dated 1889 (Plate 5) which shows a cross section of a portion of the embankment indicates that a large section of the upstream slope is constructed of "puddle clay," while the rest of the embankment is classified to be "loose filling," shown to consist of earth and rock fill. This is the only document found for the design of the embankment.

Approximate field measurements indicate that both slopes of the embankment are about 2:1 (horizontal to vertical) and the crest width of the dam is 15 feet.

(2) Appurtenant Structures. The appurtenant structures consist of two uncontrolled spillways and outlet works. The 34-foot-wide ogee crested primary spillway is located at a level about five feet below the dam crest and discharges into a stone-paved rectangular channel which terminates at a timber energy dissipator of the toe of the dam. A 50-foot-wide broad-crested emergency spillway is located on the dike between the diversion channel and the reservoir, which discharges into the diversion channel. The outlet works consist of an intake tower, a blow-off and supply line, and a valve house at the toe of the dam. Two 8-inch-diameter pipes and four 4-inch diameter pipes controlled by valves constitute the emergency drawdown facility for the dam (Plate 6). A downstream valve is also shown on Plate 6 for the 24-inch lake blow-off line. Although the valve was observed in the valve house, the city maintenance personnel had no knowledge of its operational condition or the discharge point of the 24-inch line, nor did a search of the site locate a discharge point for the 24-inch lake blow-off line.

c. Design Data

(1) Hydrology and Hydraulics. The 1921 report by Hazen, Whipple and Fuller lists the following capacities for the spillways and diversion channel: diversion channel - 2180 cfs, primary spillway - 1010 cfs, and emergency spillway - 710 cfs. The report concludes that from a hydrologic point of view the Upper Kittanning Reservoir is reasonably safe.

(2) Embankment. No data are available on the design of the dam.

(3) Appurtenant Structures. There is no design data available for the appurtenant structures.

2.2 Construction. Very limited information is available on the construction of the dam. Reference to a "present flow line" in a drawing dated 1887 (Plate 3) suggests that the dam was built prior to 1887. A drawing dated 1889 (Plate 5) also refers to an "old stone filling" and to an "old spillway." This drawing also indicates that the dam was enlarged in 1889.

As shown in Plate 4, as of 1889, flow from the watershed discharged directly into the reservoir at one time. In about 1895, a diversion channel was built to bypass the flows from Burgoon Run. The flow into the reservoir was controlled through a gated inlet structure.

Available information indicates that the dam was partially breached during a flood on May 20, 1894 which overtopped the dam. The accounts of the breach indicate that the embankment was overtopped by one foot for about 30 minutes and five major erosion ditches were formed ranging from 8 to 10 feet deep. The peak flow was reported to be 3000 cfs.

2.3 Operation. As reported by city maintenance personnel, there are no formal operating procedures for the dam. The flow into the reservoir is controlled to maintain the reservoir level at spillway crest elevation which is about five feet below the dam crest level. The blow-off and supply pipes are presently controlled by a valve located at the valve house.

2.4 Other Investigations. Available information includes the following two investigation reports: Altoona Water Works Report on the Spillway and Flood Channels, May 27, 1921, by Mr. Allen Hazen, Hazen, Whipple and Fuller Consulting Engineers, New York, New York; and a letter report addressed to the Water Commission of Pennsylvania, dated October 4, 1920, by Mr. Arthur E. Morgan, the Morgan Consulting Company, Dayton, Ohio.

2.5 Evaluation

a. Availability. The available information was obtained from the owners and PennDER files.

b. Adequacy

(1) Hydrology and Hydraulics. No design information is available.

(2) Embankment. No original design information is available. A drawing dated 1889 (Plate 5) shows the cross section of a portion of the embankment. The available information does not provide any quantitative geotechnical information to aid in the assessment of the adequacy of the design.

(3) Appurtenant Structures. Very limited information is available on the design of the outlet works. Plate 6 shows the arrangement of the blow-off valves in the valve house. No information is available on the configuration of the pipes through the embankment.

c. Operating Records. No formal operating records are available for the dam. As previously stated, the dam was overtopped prior to the construction of the diversion channel during a flood in 1894. No reference to any flooding condition was found after the completion of the diversion channel.

d. Post-Construction Changes. Available information indicates that the dam was enlarged and the presently existing spillway was constructed in 1889. In about 1895, a diversion channel was constructed to bypass the flows from Burgoon Run and to control the inflow in the reservoir.

e. Seismic Stability. The dam is located in Seismic Zone 1 and static stability of the dam is considered to be adequate based on visual observations. Therefore, according to the recommended criteria for evaluation of seismic stability of dams, the structure is assumed to present no hazard from earthquakes.

SECTION 3
VISUAL INSPECTION

3.1 Findings

a. General. The on-site inspection of the Upper Kittanning Dam consisted of:

1. Visual inspection of the embankment, abutments, and embankment toe.

2. Visual examination of the spillway and its components, the downstream end of the outlet pipe, and other appurtenant features.

3. Observation of factors affecting the runoff potential of the drainage basin.

4. Evaluation of downstream area hazard potential.

The specific observations are illustrated in Plate 7 and in the photographs in Appendix C.

b. Embankment. The general inspection of the embankment consisted of searching for indications of structural distress, such as cracks, subsidence, bulging, wet areas, seeps and boils, and observing general maintenance conditions, vegetative cover, erosion, and other surficial features. Only one wet area was observed, on the right side of the blow-off pipe discharge channel, about 100 feet downstream from the toe. No flow was observed.

Although large trees and brush have been recently removed from the downstream face of the embankment, in some areas the brush is two to three feet high and requires further clearing.

c. Appurtenant Structures. The spillway structures, spillway crests, channels, and plunge pool were examined for deterioration or other signs of distress and obstructions that would limit flow. In general, the structures were found to be in fair condition. Some seepage was observed through the joints of the stone spillway paving and around the joints of the stone crest section. The timber energy dissipator was found to be in poor condition, however, no major erosion problem was noted.

Downstream valves for the blow-off pipes were operated by city maintenance personnel and were observed to be operational. City personnel reported that the upstream valves located at the intake tower are not operational.

d. Reservoir Area. A map review indicates that the watershed area is predominantly covered with woodland; however, some portions have been strip mined. A review of the regional geology (Appendix E) indicates that the shorelines are not likely to be susceptible to massive landslides which would affect the storage volume of the reservoir or cause overtopping of the dam by displaced water.

e. Downstream Channel. While the primary spillway of the Upper Kittanning Reservoir directly discharges into the Lower Dam reservoir, the emergency spillway discharges into the diversion channel which bypasses the two downstream dams when the flows are less than the capacity of the diversion channel. Flows in excess of the diversion channel capacity would spill into the reservoirs of the downstream dams and ultimately would be discharged through the spillway of Lake Altoona Dam. Below Lake Altoona Dam, Burgoon Run flows into a rocky stream channel through residential areas of Altoona.

3.2 Evaluation. The overall condition of the Upper Kittanning Reservoir is considered to be fair, while the condition of the embankment is considered to be good, requiring only continued maintenance. The condition of the operating equipment is assessed to be poor. It is reported that the valves at the intake tower are not operational, requiring immediate maintenance and necessary repairs.

SECTION 4
OPERATIONAL FEATURES

4.1 Procedures. As reported by the maintenance personnel, there are no formal procedures for operating the dam. The operational feature of the dam which may affect the safety of the dam is the blow-off pipe valves, if it is required to lower the reservoir.

The clearing of debris from the spillway as required and the continued inspection of the facilities by the dam tender are the principal maintenance operations which would affect safety.

4.2 Maintenance of the Dam. The overall maintenance condition of the dam is considered to be fair. More frequent removal of brush from the downstream face of the dam is required.

4.3 Maintenance of Operating Facilities. City maintenance personnel reported that the upstream controls on the supply and blow-off pipe are not operational. The blow-off valves located at the downstream valve house were operated and observed to be operable. Visual observations indicate that the operating equipment is in poor condition. The condition of the downstream valve on the 24-inch lake blow-off line shown in Plate 6 is unknown, along with the location of its discharge point.

4.4 Warning System. No formal warning system exists for the dam. The dam is maintained by city personnel operating from Altoona, about three miles from the site. No communication facilities are available at the site.

4.5 Evaluation. The operational condition of the dam is considered to be poor. It is reported that the valves located at the intake tower to control flow through the blow-off and supply lines are not operational. Flow from these pipes is presently controlled by valves located at a valve house at the toe of the dam.

SECTION 5
HYDRAULICS AND HYDROLOGY

5.1 Evaluation of Features

a. Design Data. Upper Kittanning Reservoir has a direct watershed area of 0.1 square mile and receives controlled inflow from a diversion channel which bypasses the reservoir. The diversion channel has a watershed of 9.5 square miles at the reservoir.

Under normal flow conditions, runoff from the watershed bypasses the reservoir. However, with increasing flow in the diversion channel, the reservoir would start to receive uncontrolled infow through the diversion channel overflow section (Plate 2). This overflow section is located on the dike which separates the diversion channel and the reservoir. It is a 98-foot-long broad-crested section with its crest at a level about four feet four inches above the bottom of the diversion channel. Therefore, in the event of flow depths over four feet four inches in the diversion channel, the reservoir would receive uncontrolled infow.

This inflow into the reservoir would be discharged through the primary spillway to the Lower Dam and through the emergency spillway back into the diversion channel. The combined capacity of the primary and emergency spillway for the reservoir is estimated to be 1650 cfs with no freeboard.

Lower Dam and Lake Altoona Dam are located immediately downstream from this dam. It is estimated that failure of Upper Kittanning Dam would result in consequent failure of the downstream reservoirs.

b. Experience Data. Upper Kittanning Dam is classified to be an "intermediate" size dam in the "high" hazard category. Under recommended criteria for evaluating emergency spillway capacity, such impoundments are required to pass full PMF.

The adequacy of the spillway was analyzed based on the simplified procedure provided by the U.S. Army Corps of Engineers (Appendix D). Based on this procedure, it was determined that the PMF hydrograph for the stream immediately above the reservoir will have a peak flow of 23,000 cubic feet per second (cfs) and a total volume of approximately 13,000 acre-feet. Further analysis indicates that uncontrolled inflow into the reservoir through the diversion channel overflow section will equal the combined discharge capacity of the spillways when the diversion channel flow reaches about 6400 cfs, which corresponds to 28 percent of the PMF. Therefore, the dam can only pass 28 percent of PMF without overtopping.

c. Visual Observations. On the date of inspection, no conditions were observed that would indicate that the spillway of the dam could not operate satisfactorily in the event of a flood.

d. Overtopping Potential. As stated above, the dam will be overtopped during a flood whose magnitude exceeds 28 percent PMF.

e. Spillway Adequacy. As previously stated, the capacity of the spillway is less than 50 percent PMF. It is estimated that overtopping of the dam would result in failure of the dam and downstream damage potential would significantly increase compared to that which would exist just before overtopping failure, since it is estimated that failure of this dam would result in the failure of two downstream reservoirs, as stated in Section 5.1a.

Based on the above results, the spillway is classified to be "seriously inadequate" according to the recommended criteria.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations. As discussed in Section 3, the field observations did not reveal any signs of distress that would significantly affect the short-term stability of the dam at this time.

Although very limited design information is available to aid in the assessment of the structural stability of the embankment, in view of the lack of any significant signs of distress, it is considered that the structural stability can be judged based on visual observations alone.

b. Design and Construction Data

(1) Embankment. The dam was designed at a time (circa 1887) when limited understanding of the geotechnical behavior of earth structures existed. Consequently, the available design and construction information includes no quantitative data to aid in the assessment of embankment stability.

(2) Appurtenant Structures. No information is availabe on the structural design of the outlet works.

c. Operating Records. The structural stability of the dam is not considered to be affected by the operational features of the dam.

d. Post-Construction Changes. As discussed in Section 2.2, the dam was enlarged in 1894. Plates 3 and 5 illustrate this post-construction change.

SECTION 7
ASSESSMENT AND RECOMMENDATIONS/REMEDIAL MEASURES

7.1 Dam Assessment

a. Assessment. The visual observations and review of available information indicate that the Upper Kittanning Dam is in fair condition. Field observations did not reveal any significant signs of distress and none were reported in the past.

The condition of the operational facilities was considered to be poor and it was reported that the valves at the intake tower are not operational.

The spillway is considered to be "seriously inadequate" because its capacity (28 percent PMF) is less than 50 percent PMF and because it is estimated that overtopping of the embankment would result in failure, significantly increasing the downstream hazard potential which existed just prior to overtopping.

b. Adequacy of Information. The available information in conjunction with visual observations and previous experience of the inspectors are considered to be sufficient to make a reasonable assessment of the dam.

c. Urgency. More detailed evaluation of the spillway and diversion channel hydraulics should be made immediately and other recommendations below should be implemented as soon as practicable or on a continuing basis.

d. Necessity for Further Investigation. The adequacy of the spillway is considered to require immediate further investigation. The embankment is considered to require no further investigation.

7.2 Recommendations/Remedial Measures

1. The owner should initiate additional hydrology and hydraulic studies to more accurately ascertain the spillway capacity and to determine the nature and extent of remedial measures required to increase the spillway capacity.

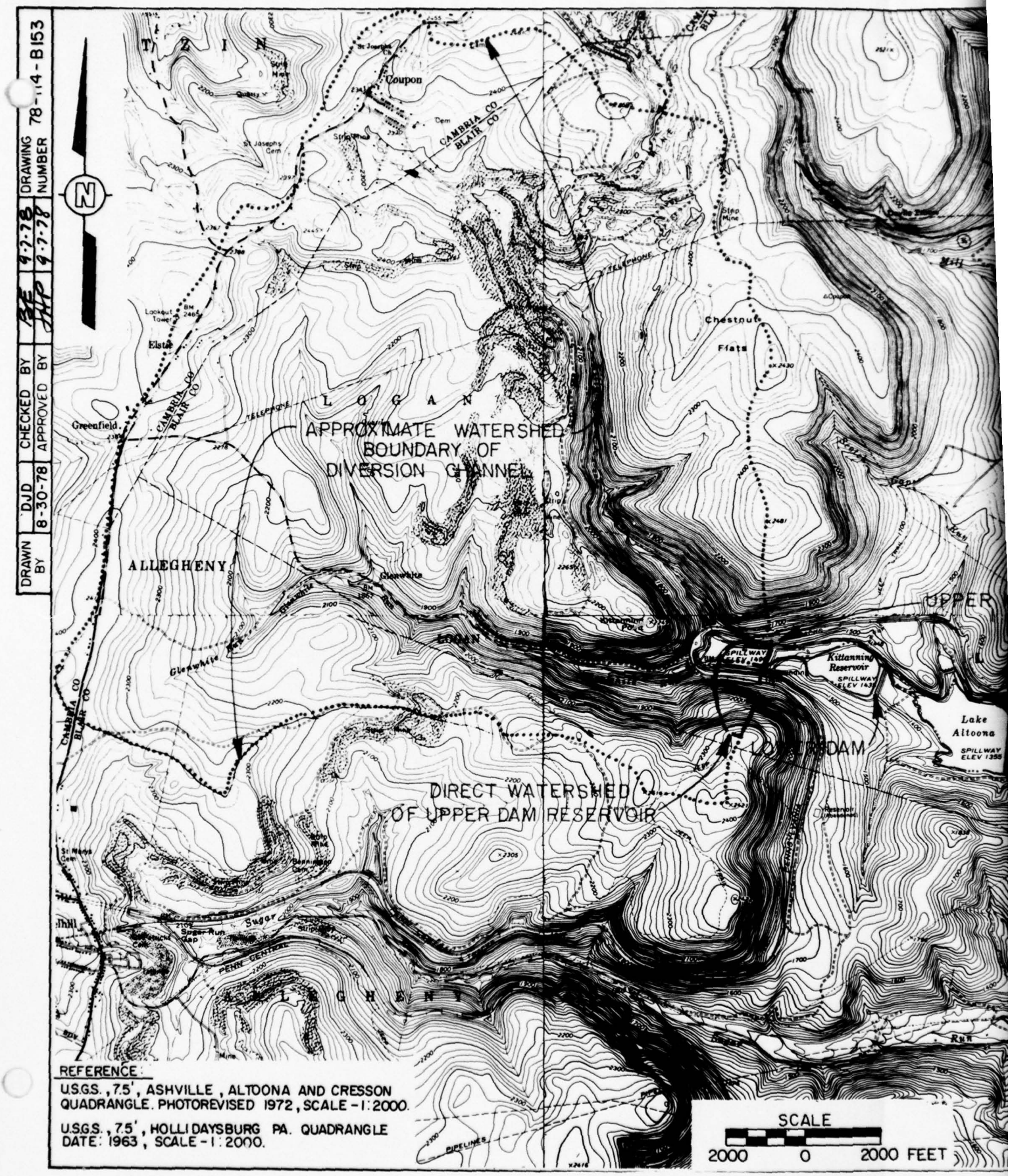
2. It is recommended that the owner provide around-the-clock surveillance during unusually heavy runoff and develop a formal warning system to alert the downstream residents in the event of an emergency.

3. It is recommended that the owner immediately evaluate the operational condition of the upstream valves, perform necessary maintenance, and adequately maintain the equipment. It is also recommended that necessary steps be taken to evaluate the structural integrity of the pipes through the embankment.

4. Brush and trees should be removed from the downstream face of the dam and for a distance of at least 50 feet below the toe of the dam to permit adequate inspection of these areas in future inspections.

5. It is recommended that the owner be advised that the dam and appurtenant structures be inspected regularly and necessary maintenance should be performed.

PLATES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Elsta
Greenfield
Chestnut Flats
Glenwhite
Kittanning Reservoir
SPILLWAY ELEV 1439
Lake Altoona
SPILLWAY ELEV 1355
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CAMBRIA CO
BLAIR CO
TELEPHONE
PENN CENTRAL
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PLATE I

UPPER KITTANNING DAM

VICINITY, FLOOD PLAIN AND WATERSHED MAP

D'APPOLONIA

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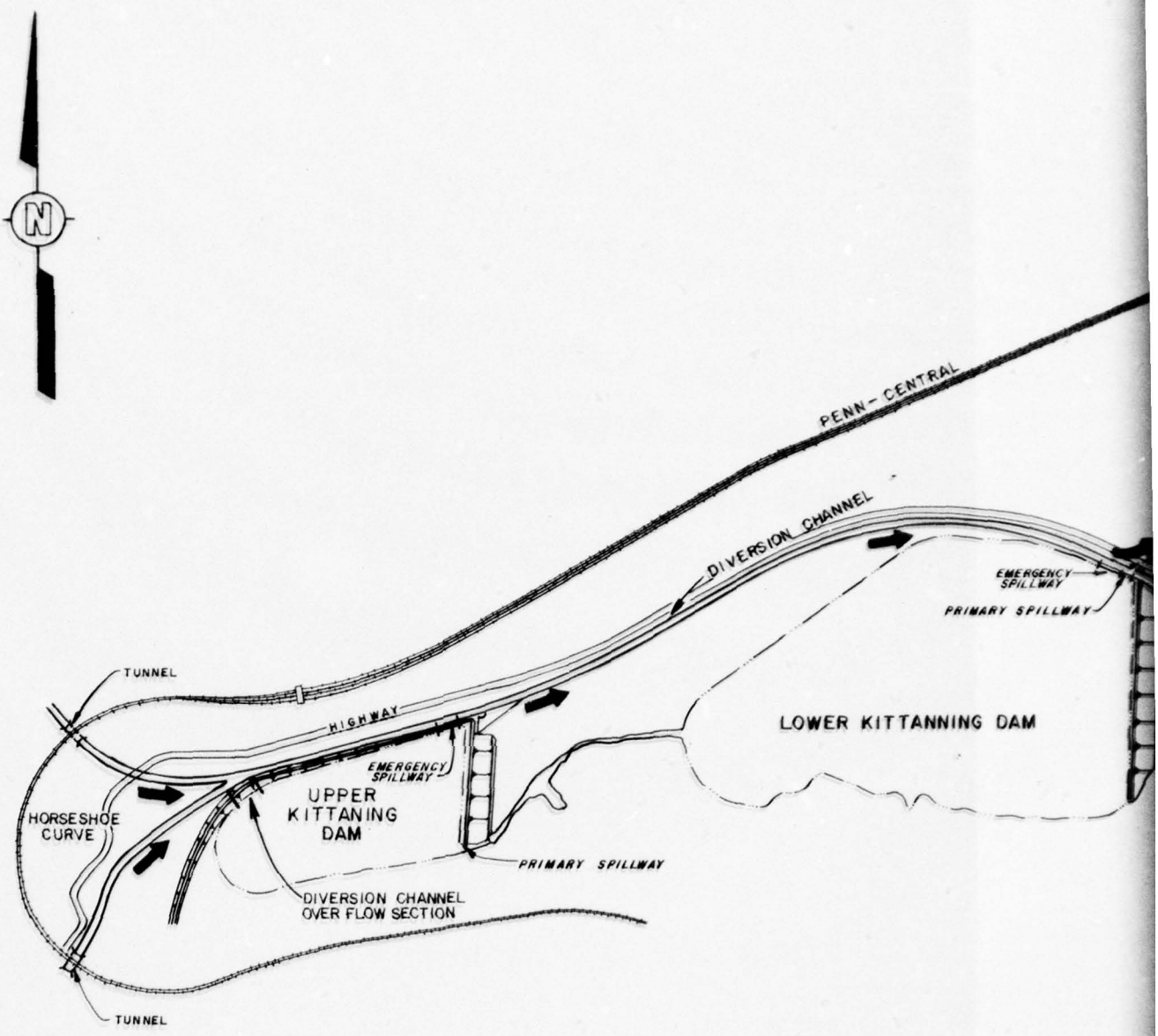

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→ COURSE OF NORMAL FLOW

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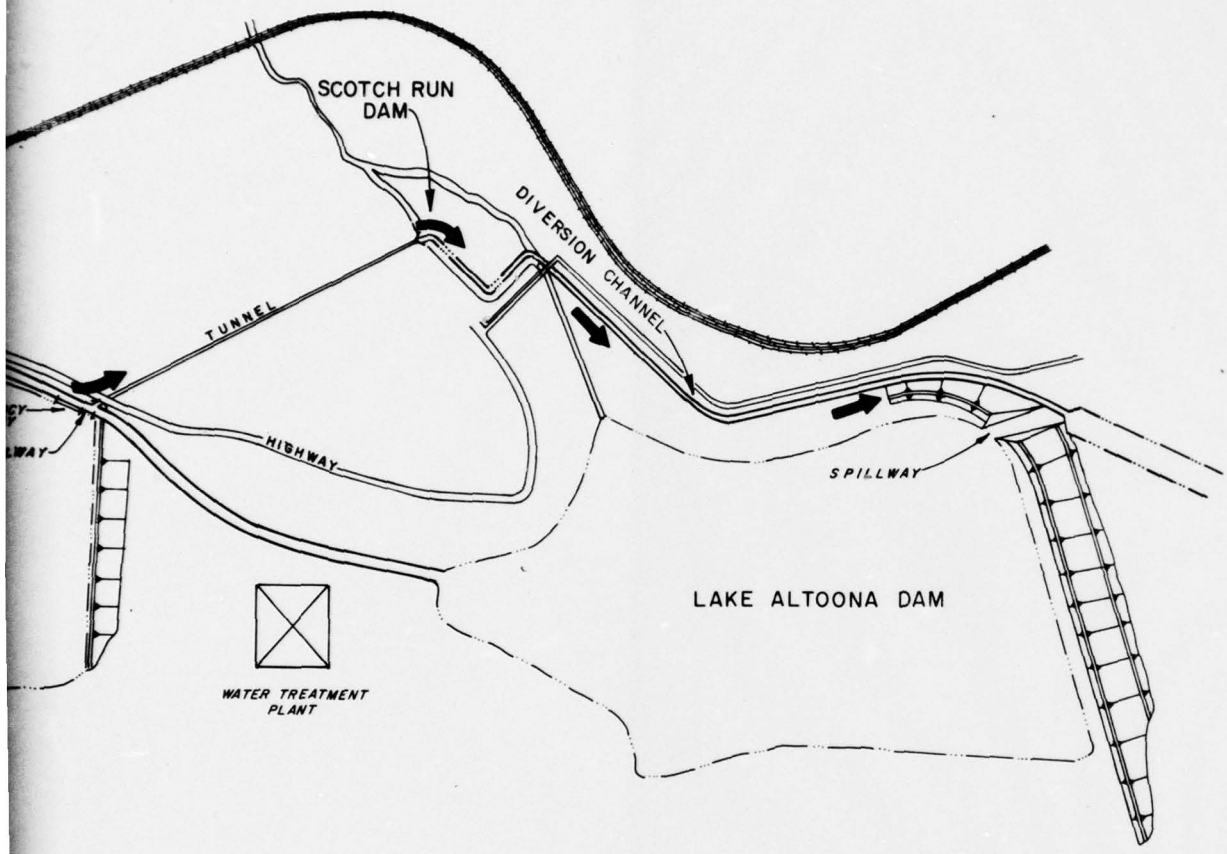


PLATE 2

UPPER KITTANNING DAM

DIVERSION CHANNEL PLAN

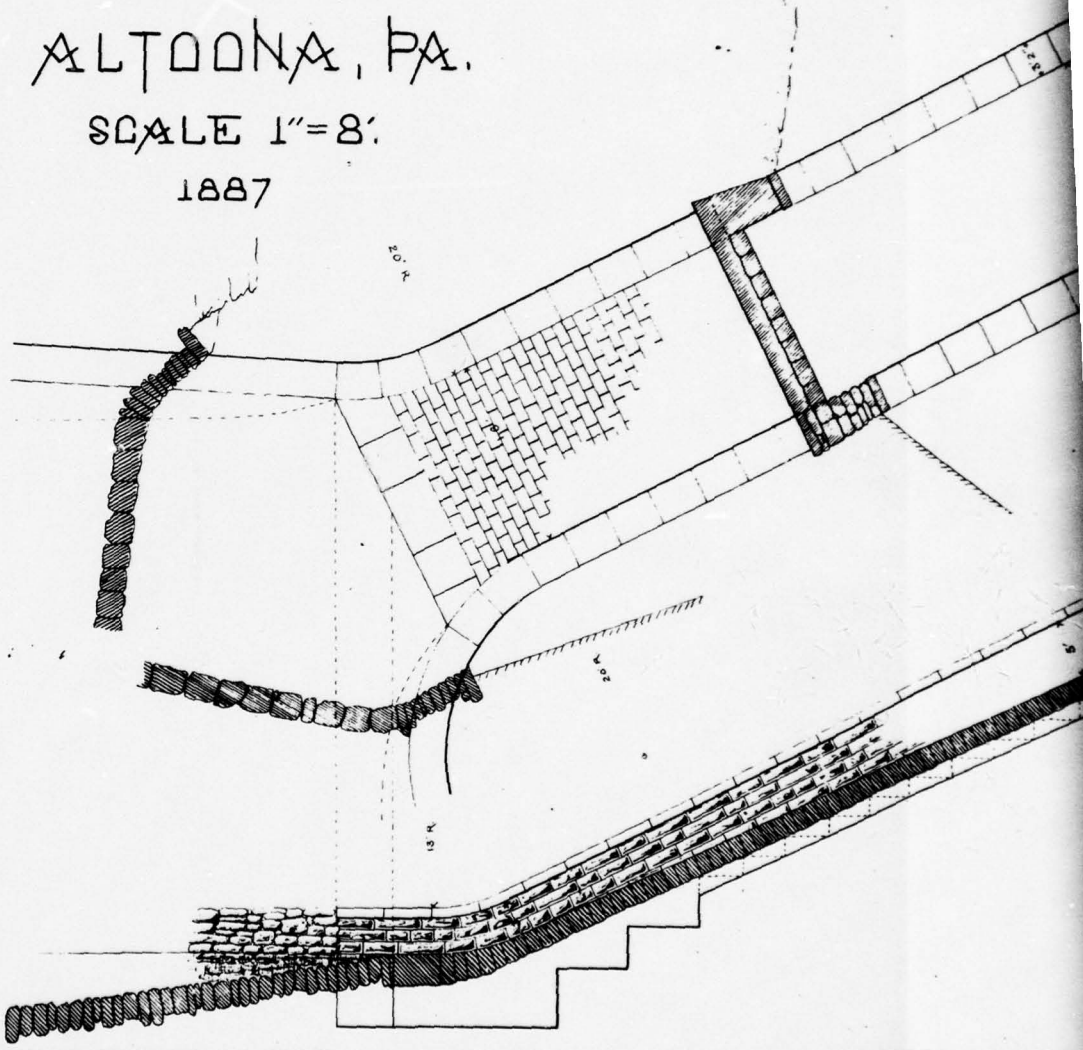
D'APPOLONIA

DRAWN BY	D.J.D.	CHECKED BY	RE	9-7-78	DRAWING NUMBER	78-114-B151
	8-30-78	APPROVED BY	THP	9-7-78		

KITTANNING POINT RES.
SPILL-WAY.
ALTOONA, PA.

SCALE 1"=8'

1887



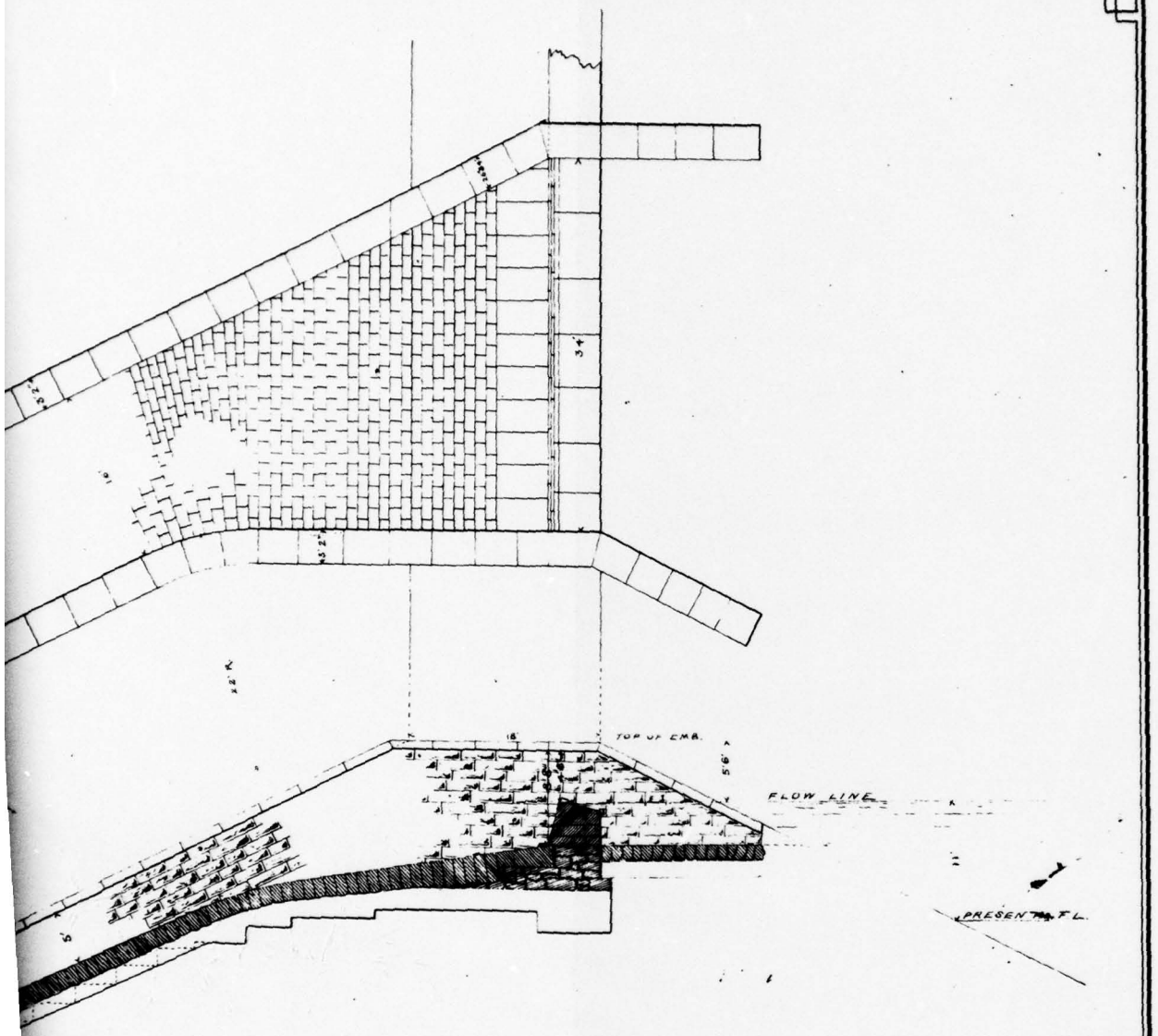
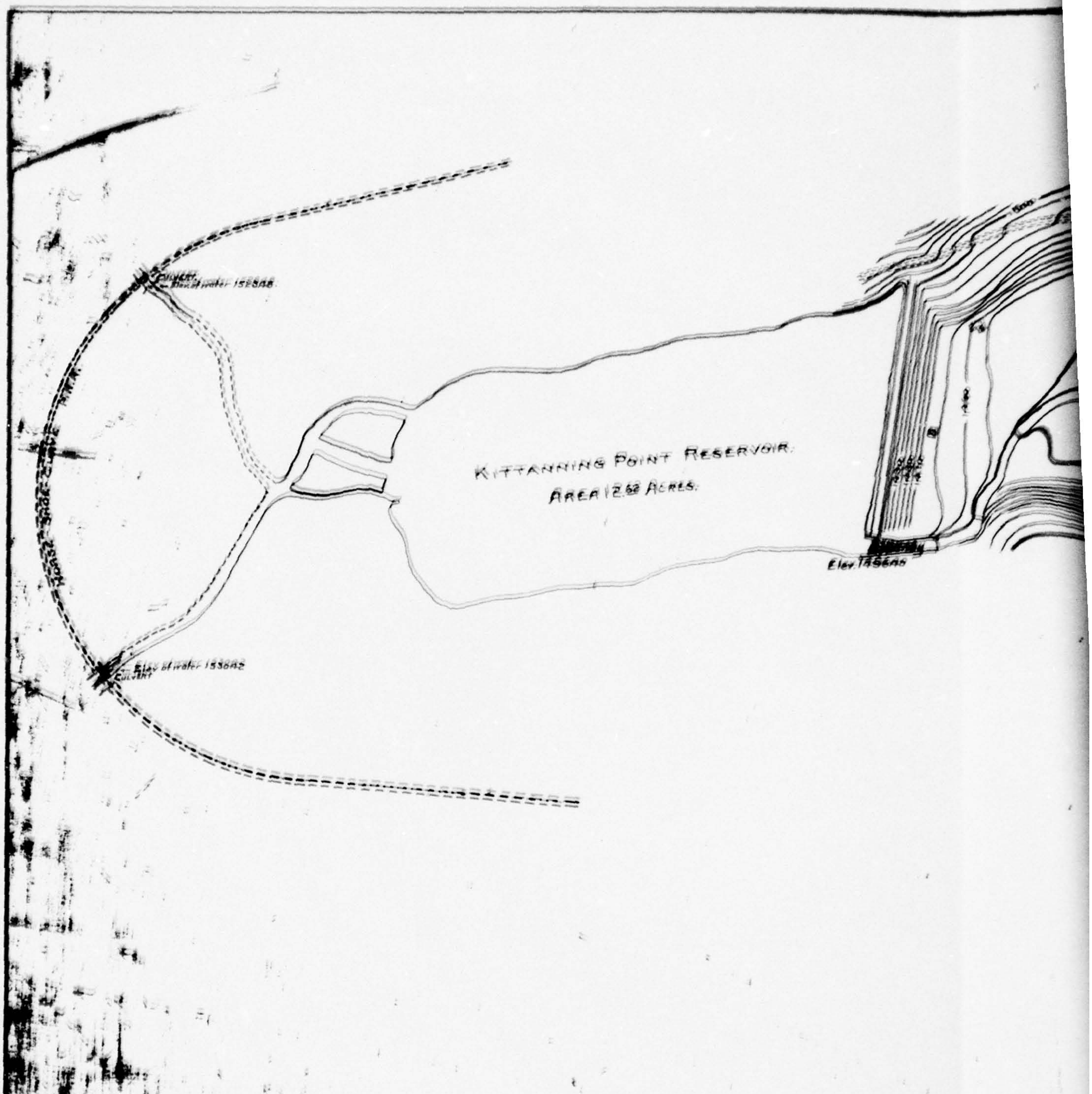
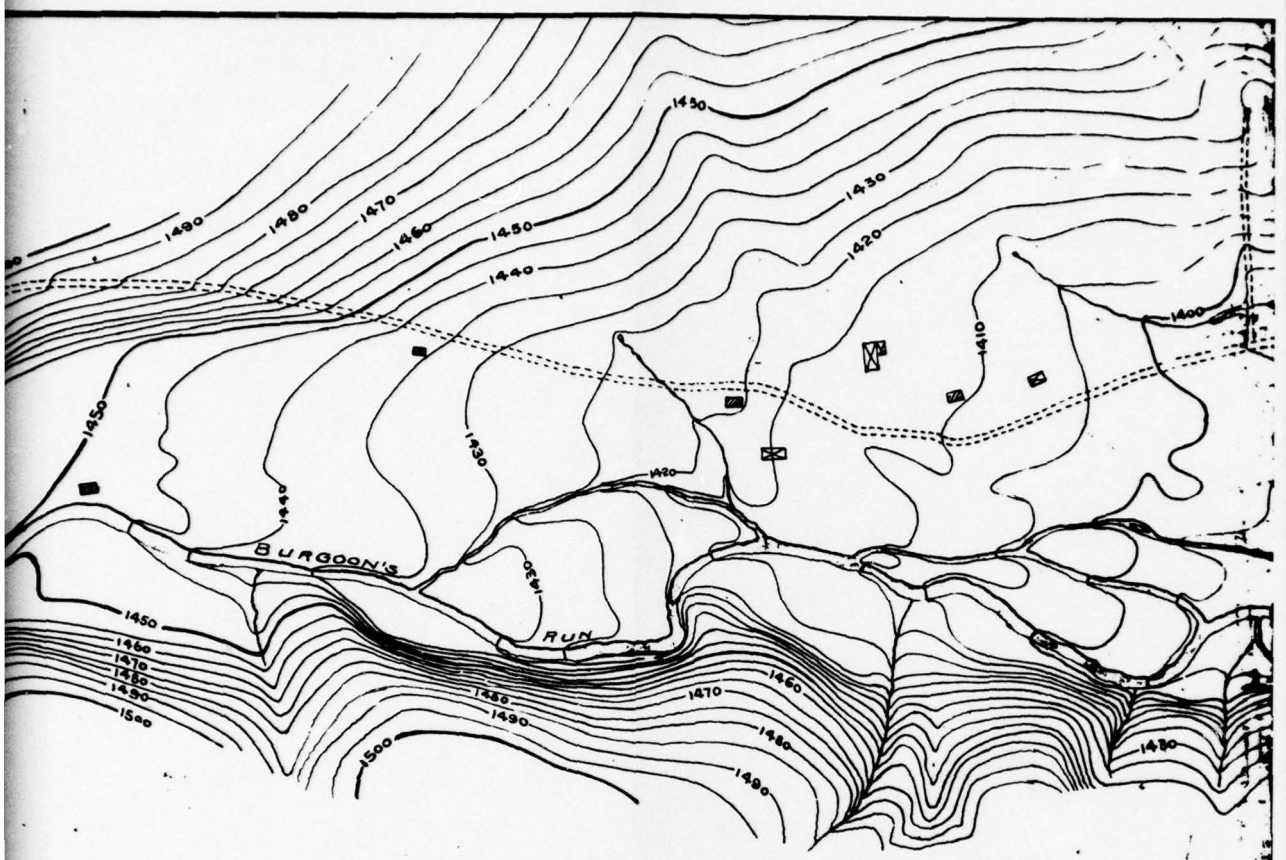


PLATE 3

D'APPOLONIA

DRAWN BY	D.J.D.	CHECKED BY	[illegible]	9-7-78	DRAWING NUMBER	78-114-B149
	8-30-78	APPROVED BY	[illegible]	9-7-78		





No. 344

Topographical map of site of

THE PROPOSED IMPOUNDING RESERVOIR.

FOR THE

CITY OF ALTOONA, BLAIR CO., PA.

BELOW KITTANNING POINT RESERVOIR.

SCALE 1 INCH = 200 FEET. ALTOONA, PA., DECEMBER, 1889.

CONTOURS 5 FEET. Harvey Linton, CITY ENGINEER.

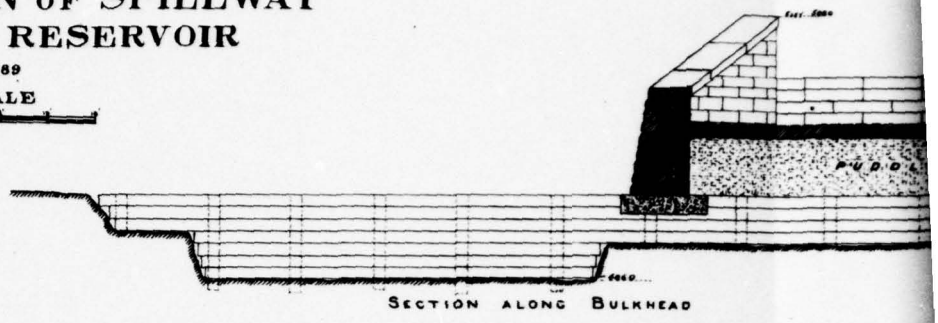
PLATE 4

D'APPOLONIA

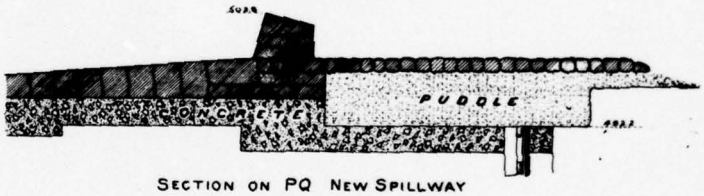
DETAILS
CONSTRUCTION OF SPILLWAY
KIT. POINT RESERVOIR

1889

SCALE

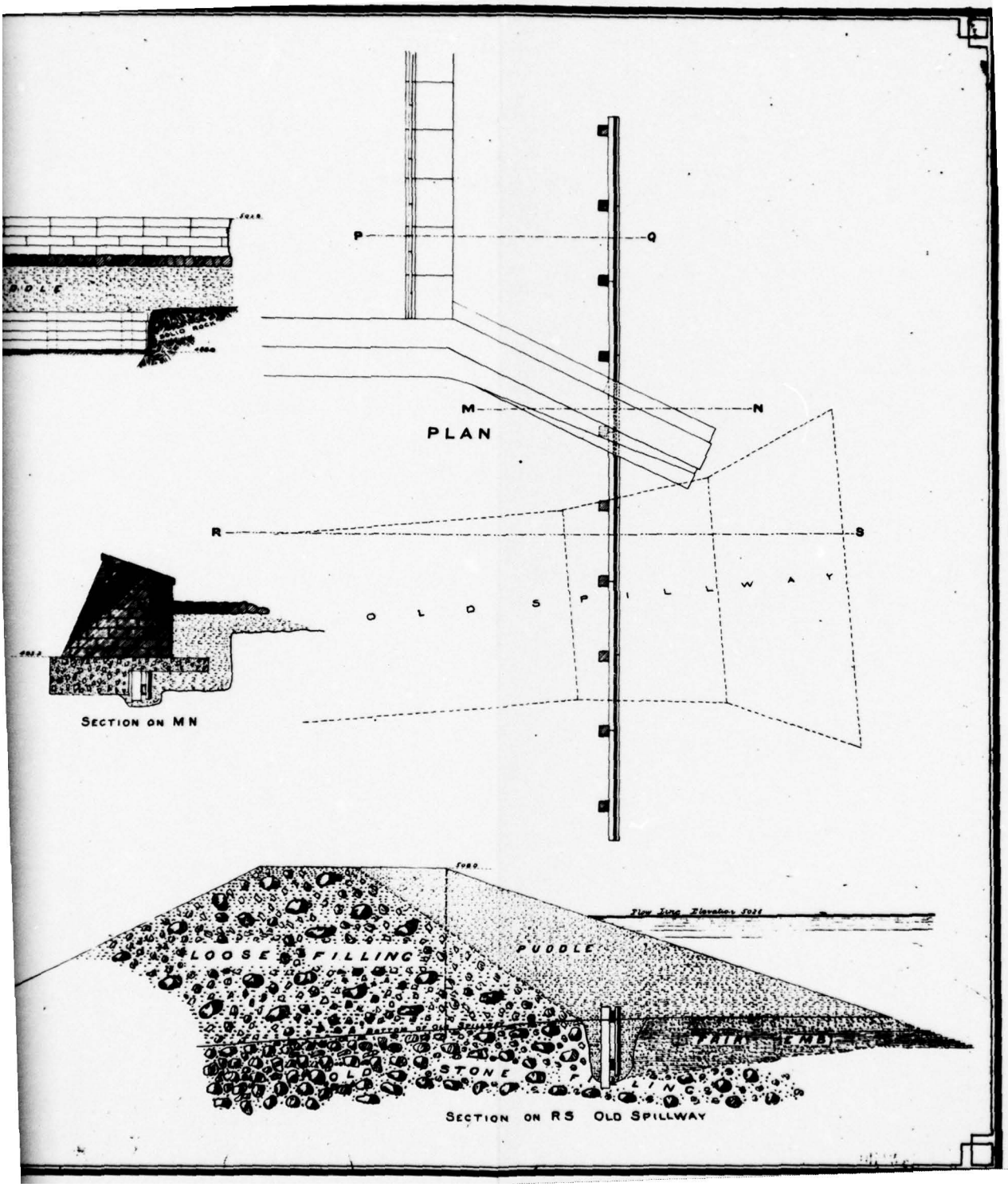


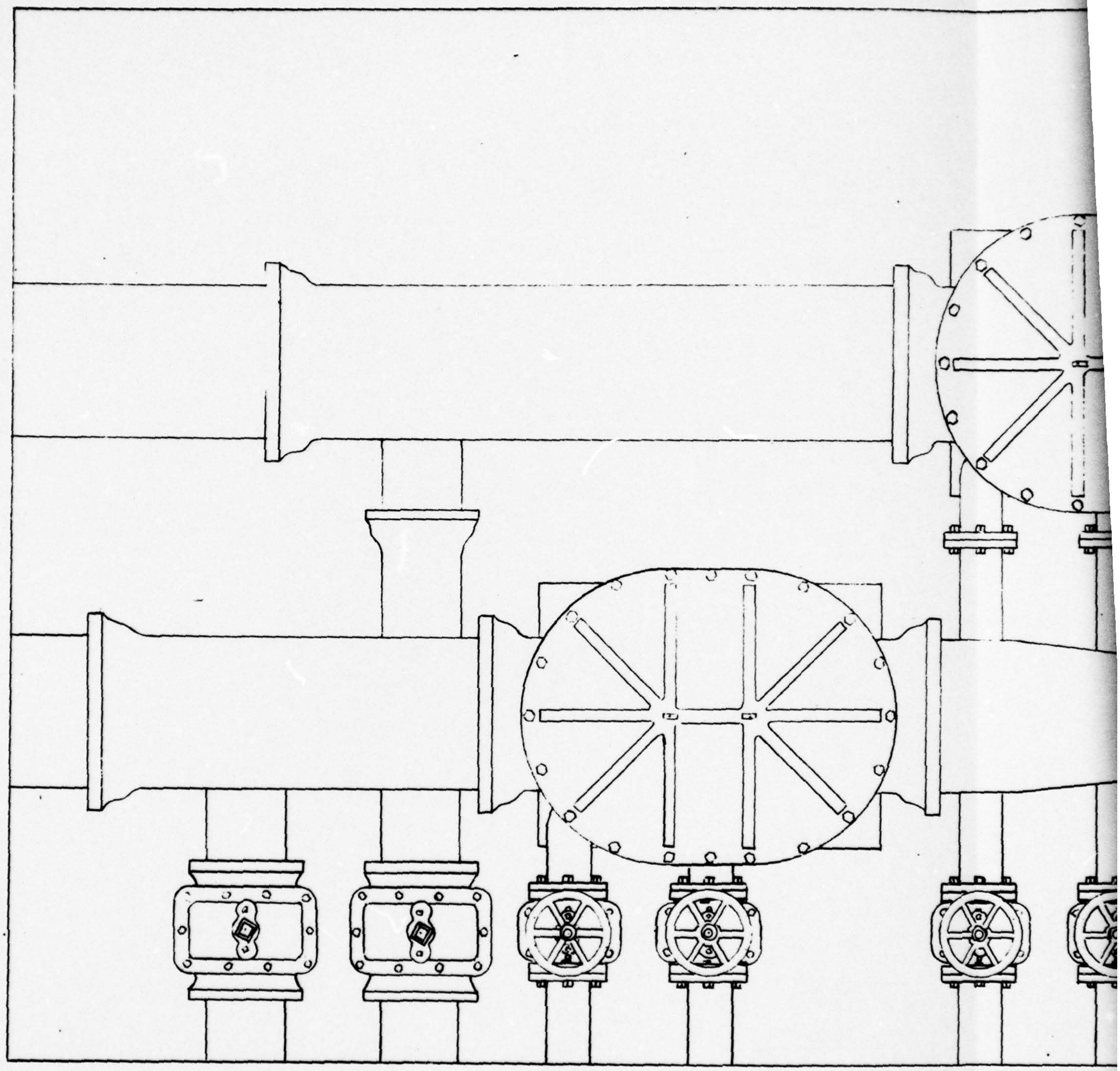
SECTION ALONG BULKHEAD



SECTION ON PQ NEW SPILLWAY

Note - The loose filling to the right of the dotted line in Section on RS is to be replaced by stone puddle.


P
Q
M
N
PLAN
R
S
O L D S P I L L W A Y
SECTION ON MN
LOOSE FILLING
PUDDLE
STONE
SECTION ON RS OLD SPILLWAY

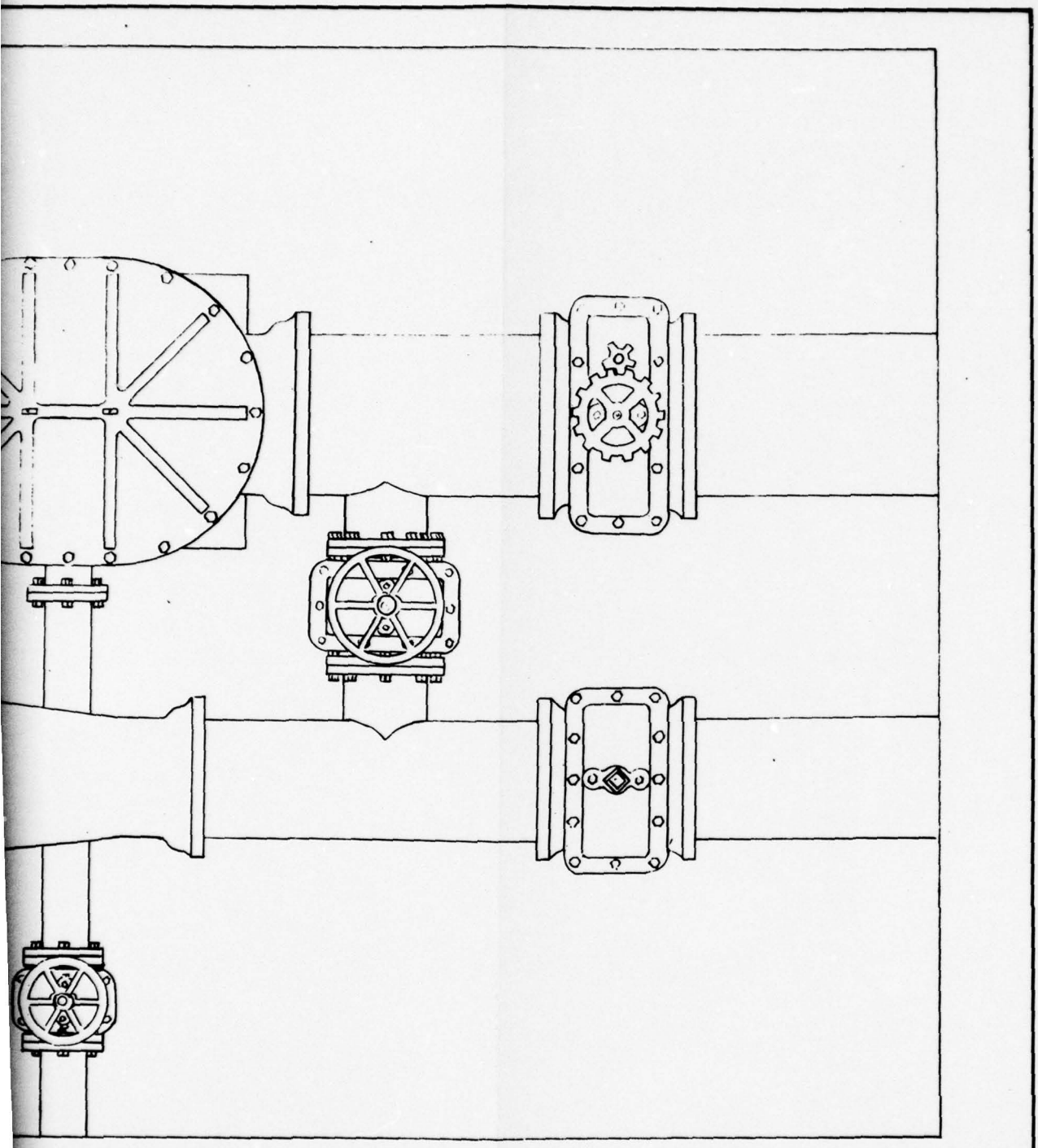


DRAWN BY	Trs 9-5-78	CHECKED BY	9-2-78	DRAWING NUMBER	7_14-B157
		APPROVED BY	9-7-78		

SCREEN POT & VA

KIT. PT. RES. GATE

SCALE 3-4" = 1'

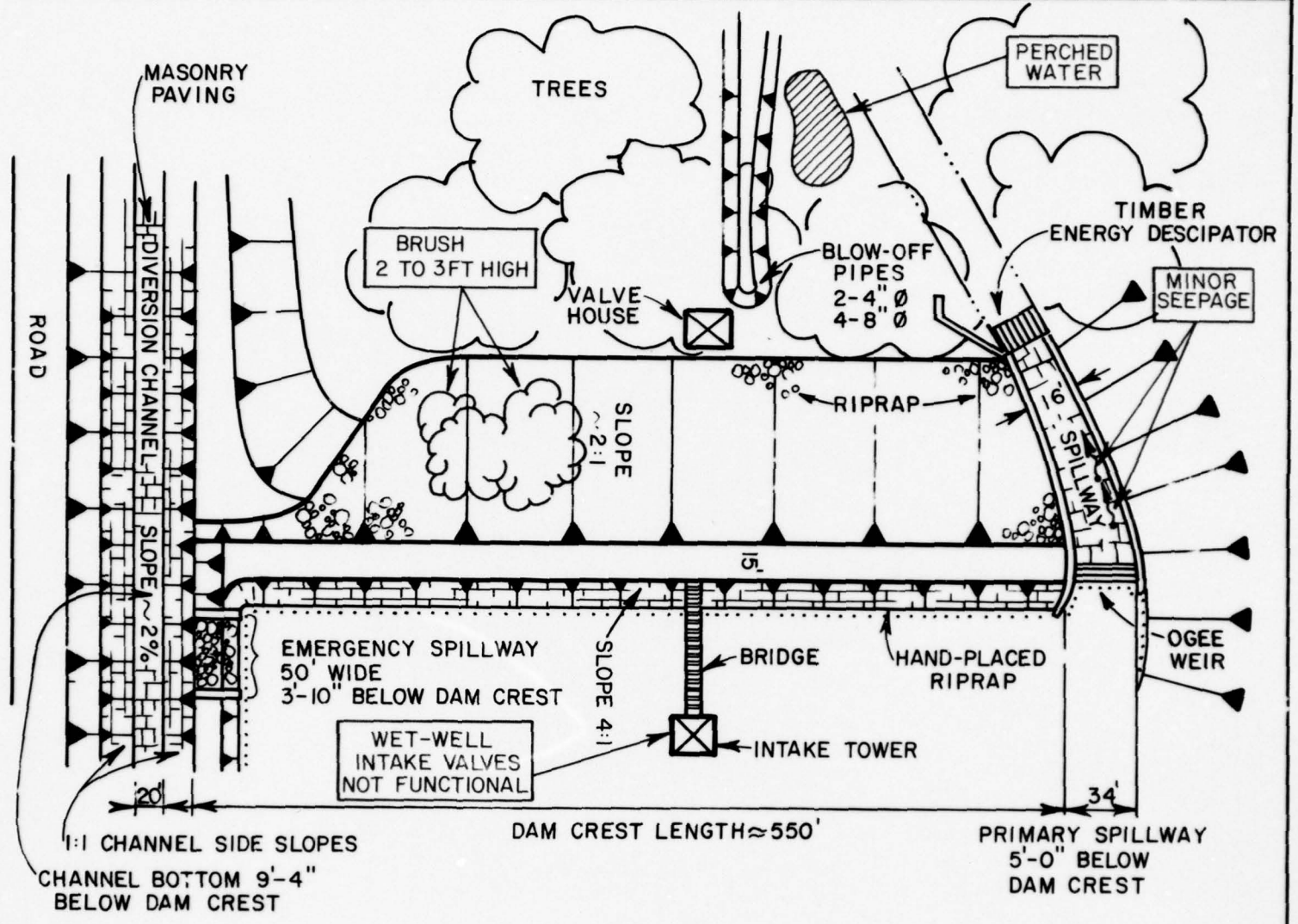


ALVES
E HOUSE

PLATE 6

D'APPOLONIA

DRAWN BY	MBM	CHECKED BY	BE	9-7-78	DRAWING NUMBER	114-A22
	8-25-78	APPROVED BY	JHP	9-7-78		



POOL LEVEL DATE OF INSPECTION : 5'-0 BELOW DAM CREST

PLATE 7

UPPER KITTANING DAM NDI ID:530

GENERAL PLAN
FIELD INSPECTION NOTES
FIELD INSPECTION DATE : AUGUST 8, 1978

DAPPOLONIA

APPENDIX A

CHECKLIST
VISUAL INSPECTION
PHASE I

CHECKLIST
VISUAL INSPECTION
PHASE I

NAME OF DAM UPPER KITTANING RES. COUNTY BLAIR STATE PA ID# NDI: 530
DER: 7-13

TYPE OF DAM EARTH FILL. HAZARD CATEGORY HIGH

DATE(S) INSPECTION AUGUST 8, 1978 WEATHER SUNNY TEMPERATURE 80's

POOL ELEVATION AT TIME OF INSPECTION 1491 M.S.L. TAILWATER AT TIME OF INSPECTION 1450± M.S.L.

INSPECTION PERSONNEL:

BILGIN EREL
WAH-TAK CHAN

REVIEW INSPECTION BY:
AUGUST 16 1978

ELIO D'APPOLONIA
L.D. ANDERSEN
JAMES POELLOT

BILGIN EREL. RECORDER

VISUAL INSPECTION
PHASE I
EMBANKMENT

NAME OF DAM UPPER KITTANNING RES.
ID# NDI : 530 DER : 7-13

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	NONE FOUND.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	NONE FOUND.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	NONE FOUND.	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	NO PERCEIVABLE MISALIGNMENT.	
RIPRAP FAILURES	NONE FOUND.	

VISUAL INSPECTION
PHASE I
EMBANKMENT

NAME OF DAM UPPER KITTANNING RES.
ID# NDI:530 DER:7-13

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	NO VISUAL SIGNS OF DISTRESS, NO SEEPAGE.	
ANY NOTICEABLE SEEPAGE	PERCHED WATER ABOUT 100-FT DOWNSTREAM of TOE. NO NOTICABLE SEEPAGE.	SEE PLATE-7 FOR LOCATION.
STAFF GAGE AND RECORDER	NONE	
DRAINS	NONE	

VISUAL INSPECTION
PHASE I
CONCRETE/MASONRY DAMS

NAME OF DAM UPPER KITTANNING RES.
ID# NDI: 530 DEP: 7-13

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ANY NOTICEABLE SEEPAGE	EARTH FILL DAM N/A	
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	N/A	
DRAINS	N/A	
WATER PASSAGES	N/A	
FOUNDATION	N/A	

VISUAL INSPECTION
PHASE I
CONCRETE/MASONRY DAMS

NAME OF DAM UPPER KITTANING RES.
ID# NDI ; 530 DER ; 7-13

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	EARTHFILL DAM. N/A	
STRUCTURAL CRACKING	N/A	
VERTICAL AND HORIZONTAL ALIGNMENT	N/A	
MONOLITH JOINTS	N/A	
CONSTRUCTION JOINTS	N/A	
STAFF GAGE OF RECORDER:		

VISUAL INSPECTION
PHASE I
OUTLET WORKS

NAME OF DAM UPPER KITTANNING RES
ID# NDI: 530 DEP: 7-13

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	OUTLET PIPES ARE CAST IRON. ONLY THE DOWNSTREAM END OF 6 PIPES (2ϕ8" & 4ϕ4") ARE VISIBLE.	
INTAKE STRUCTURE	INTAKE TOWER (WET)	
OUTLET STRUCTURE	NO OUTLET STRUCTURE. BLOW-OFF PIPES DIRECTLY DISCHARGE INTO THE RIPRAPPED DISCHARGE CHANNEL.	
OUTLET CHANNEL	EARTH CHANNEL	
EMERGENCY GATE	CITY PERSONNEL OPERATED THE SIX VALVES ON THE BLOW-OFF PIPES. VALVES FOUND TO BE FUNCTIONAL.	

VISUAL INSPECTION
PHASE I
UNGATED SPILLWAY

NAME OF DAM UPPER KITTANING RES.
ID# NDI: 530 DER: 7-13

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	PRIMARY: 34-FOOT WIDE OGEE CRESTED WEIR. EMERGENCY: 100-FT WIDE BROAD-CRESTED WEIR.	
APPROACH CHANNEL	FOR BOTH SPILLWAYS: LAKE.	
DISCHARGE CHANNEL	PRIMARY SPILLWAY: RECTANGULAR MASONRY CHANNEL EMERGENCY SPILLWAY: DIVERSION CHANNEL.	
BRIDGE AND PIERS	NONE.	

VISUAL INSPECTION
PHASE I
GATED SPILLWAY

NAME OF DAM UPPER KITTANNING RES.
ID# NDI: 530 DER: 7-13

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	NO GATED SPILLWAY. N/A.	
APPROACH CHANNEL	N/A.	
DISCHARGE CHANNEL	N/A.	
BRIDGE PIERS	N/A.	
GATES AND OPERATION EQUIPMENT	N/A.	

VISUAL INSPECTION
PHASE I
INSTRUMENTATION

NAME OF DAM UPPER KITTANNING RES.
ID# NDI: 530 DER: 7-13

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	NONE	
OBSERVATION WELLS	NONE	
WEIRS	NONE	
PIEZOMETERS	NONE	
OTHER	NONE.	

VISUAL INSPECTION
PHASE I
RESERVOIR

NAME OF DAM UPPER KITTANNING RES.
ID# NDI: 530 DER: 7-13

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	WOODED, STEEP.	
SEDIMENTATION	UNKNOWN	

VISUAL INSPECTION
PHASE I
DOWNSTREAM CHANNEL

NAME OF DAM UPPER KITTANNING RES.
ID# NDI: 530 DER: 7-13

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	ABOUT 1000 FT LONG NATURAL STREAM CHANNEL WHICH DISCHARGES INTO LOWER DAM RESERVOIR.	
SLOPES	N/A.	
APPROXIMATE NUMBER OF HOMES AND POPULATION	IT IS ESTIMATED THAT FAILURE OF THIS DAM WOULD RESULT IN FAILURE OF TWO DOWNSTREAM RESERVOIRS AN COMBINE DISCHARGE THROUGH ALTOONA.	MAIN IMPACT AREA OF FLOOD : ≈ 500 HOMES, POPULATION ≈ 2000. FURTHER DAMAGE AND LIFE LOSS IS ALSO POSSIBLE.

APPENDIX B

CHECKLIST
ENGINEERING DATA, DESIGN,
CONSTRUCTION, OPERATION
PHASE I

CHECKLIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM UPPER KITTANNING RES.
ID# NDI: 530 DER: 7-13

ITEM	REMARKS
AS-BUILT DRAWINGS	VERY LIMITED NUMBER OF DRAWINGS ARE AVAILABLE IN OWNER'S FILES.
REGIONAL VICINITY MAP	SEE PLATE 1.
CONSTRUCTION HISTORY	AVAILABLE INFORMATION SUGGEST THE DAM WAS DESIGN BY MR. C. W. KNIGHT CONSULTING ENG. FROM ROME, NEWYORK IN ABOUT (1887~1889). CONSTRUCTION COMPLETED IN ABOUT 1889.
TYPICAL SECTIONS OF DAM	NOT AVAILABLE. SEE PLATE 5 FOR A PARTIAL CROSS-SECTION.
OUTLETS - PLAN - DETAILS - CONSTRAINTS - DISCHARGE RATINGS	SEE PLATE 6 (THE ONLY AVAILABLE INFORMATION ON OUTLET WORKS)

CHECKLIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM UPPER KITTANNING RES.
ID# NDI: 530 DER: 7-13

ITEM	REMARKS
RAINFALL/RESERVOIR RECORDS	RECORDED BY DAM TENDER AT LAKE ALTOONA DAM ABOUT ONE MILE DOWNSTREAM FROM THIS DAM.
DESIGN REPORTS	NOT AVAILABLE
GEOLOGY REPORTS	NOT AVALABLE.
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	NOT AVAILABLE.
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	NOT AVAILABLE.

CHECKLIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM UPPER KITTANNING RES
ID# NDI:530 DER:7-13

ITEM	REMARKS
POST CONSTRUCTION SURVEYS OF DAM	NONE REPORTED.
BORROW SOURCES	UNKNOWN
MONITORING SYSTEMS	NONE.
MODIFICATIONS	AVAILABLE INFORMATION SUGGEST A NEW SPILLWAY WAS CONSTRUCTED IN 1889.
HIGH POOL RECORDS	THE DAM WAS OVERTOPPED IN 1894. PRIOR TO THE CONSTRUCTION OF THE DIVERSION CHANNEL.

CHECKLIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM UPPER KITTANNING RES.
ID# NDI : 530 DER : 7-13

ITEM	REMARKS
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	ALTOONA WATER WORKS : REPORT ON SPILLWAYS AND FLOOD CHANNEL MAY 27, 1921 BY ALLEN HAZEN A LETTER REPORT ON SPILLWAY AND FLOOD CHANNEL OCT 4, 1921 BY ARTHUR E. MORGAN.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	THE DAM WAS OVERTOPPED IN 1894 CAUSING ABOUT SIX EROSION DITCHES ACCROSS THE CREST 8 TO 10 FT DEEP.
MAINTENANCE OPERATION RECORDS	NOT AVAILABE.
SPILLWAY PLAN SECTIONS DETAILS	SEE PLATE 3
OPERATING EQUIPMENT PLANS AND DETAILS	SEE PLATE 7.

NAME OF DAM UPPER KITTANING DAM.

ID# NDI: 530 DER: 7-13

CHECKLIST
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: WOODED, SOME STRIP MINNING 9.6 SQ.MI.

ELEVATION; TOP NORMAL POOL AND STORAGE CAPACITY: 200 AC-FT @ EL. 1496

ELEVATION; TOP FLOOD CONTROL POOL AND STORAGE CAPACITY: SAME AS ABOVE

ELEVATION; MAXIMUM DESIGN POOL: EL 1497 (EMERGENCY SPILLWAY CREST)

ELEVATION; TOP DAM: EL 1501

CREST: (SPILLWAY)	PRIMARY	EMERGENCY
a. Elevation	1496	1497
b. Type	OGEE	BROAD-CREST
c. Width	N/A	15'-0
d. Length	34'-0	100'-0
e. Location Spillover	RIGHT ABUTMENT	LEFT ABUTMENT
f. Number and Type of Gates	NONE	NONE

OUTLET WORKS:

a. Type ϕ16" & ϕ 24" PIPES DISCHARGING THROUGH 2ϕ8" & 4ϕ4" PIPES.

b. Location MIDDLE OF THE DAM.

c. Entrance Inverts UNKNOWN

d. Exit Inverts UNKNOWN.

e. Emergency Draindown Facilities 2ϕ8" & 4ϕ4" PIPE (AS PRESENTLY OPERATED)

HYDROMETEOROLOGICAL GAGES:

a. Type RAIN GAGE

b. Location AT LAKE ALTOONA DAM

c. Records AVAILABLE IN CITY RECORDS.

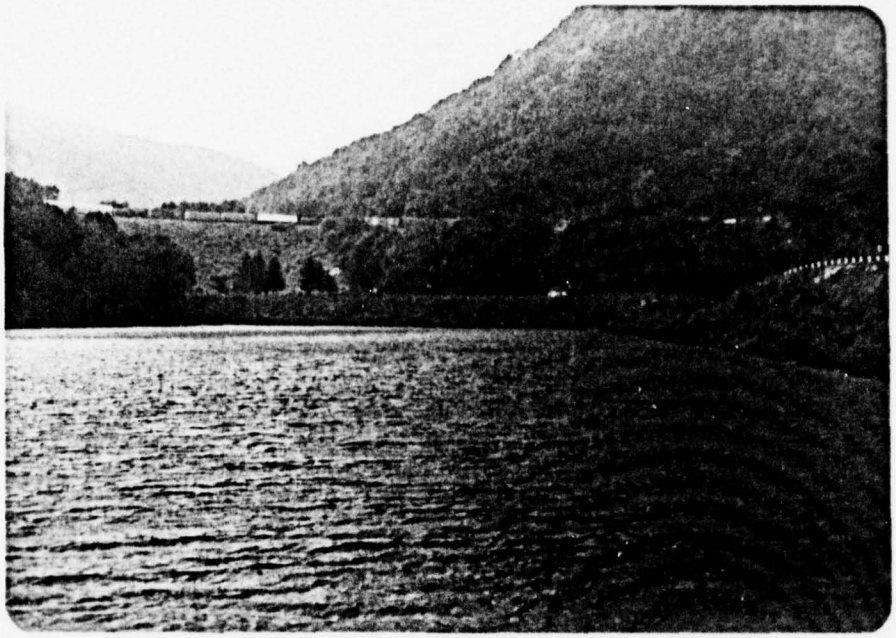
MAXIMUM NONDAMAGING DISCHARGE: SPILLWAY CAPACITY ≈ 1600 CFS.

APPENDIX C

PHOTOGRAPHS

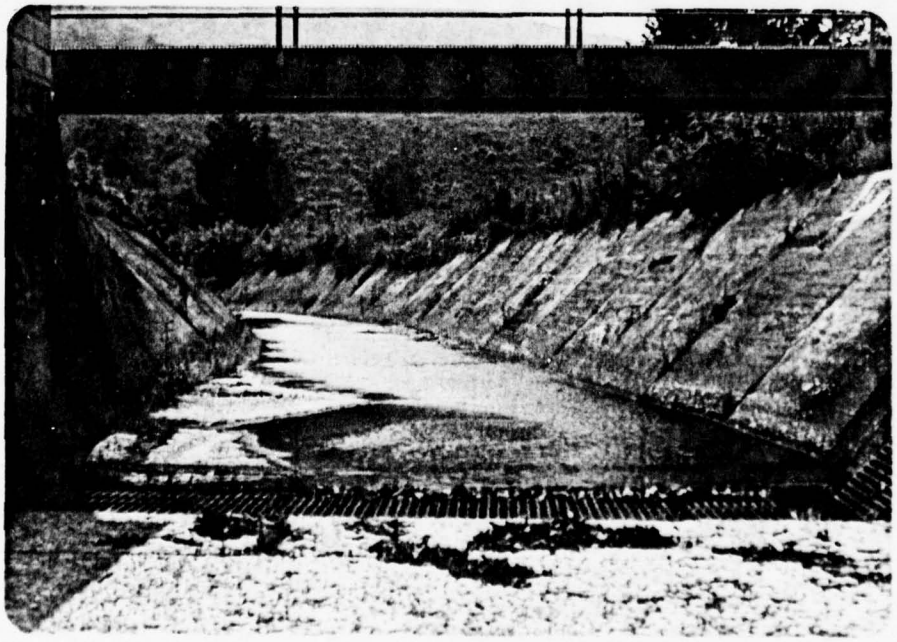
LIST OF PHOTOGRAPHS
UPPER KITTANNING DAM
NDI I.D. NO. 530
AUGUST 8, 1978

PHOTOGRAPH NO.	DESCRIPTION
1	Reservoir (horseshoe curve in background).
2	Diversion channel (looking upstream, foreground reservoir intake).
3	Crest (looking south).
4	Primary spillway chute.
5	Emergency spillway and diversion channel.
6	Crest of primary spillway.
7	Valve house.
8	Blow-off pipe (four 4-inch-diameter and two 8-inch-diameter pipes).
9	Blow-off pipes discharging.
10	Downstream: Lower Dam.



Photograph No. 1

Reservoir (horseshoe curve in background).

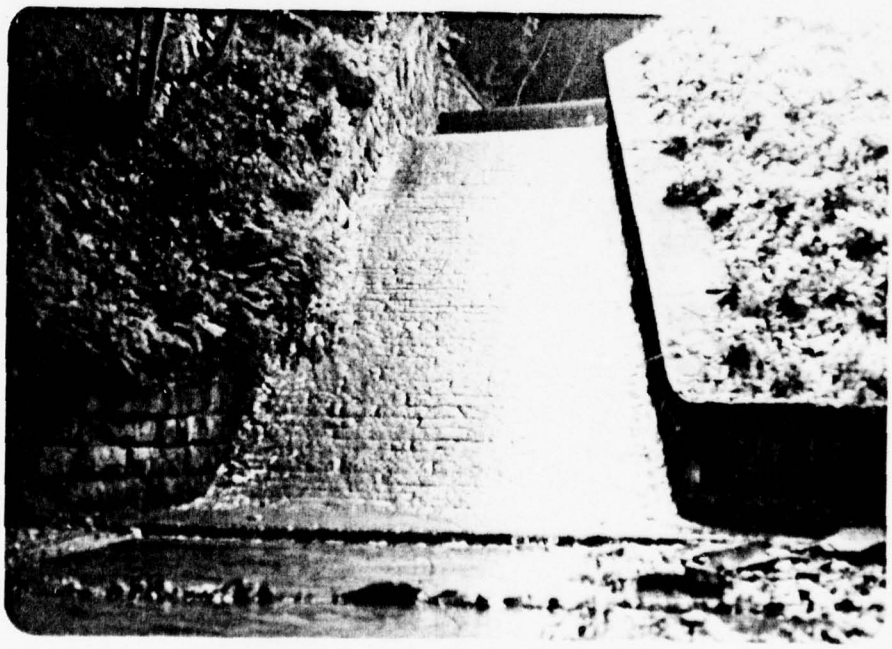


Photograph No. 2

Diversion channel (looking upstream, foreground reservoir intake).

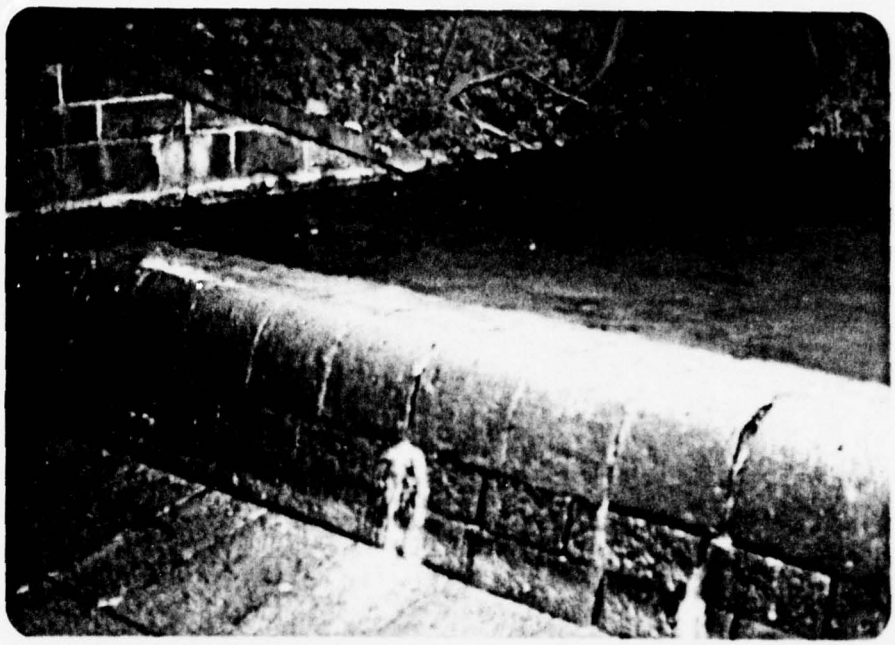
Photograph No. 3

Crest (looking south).



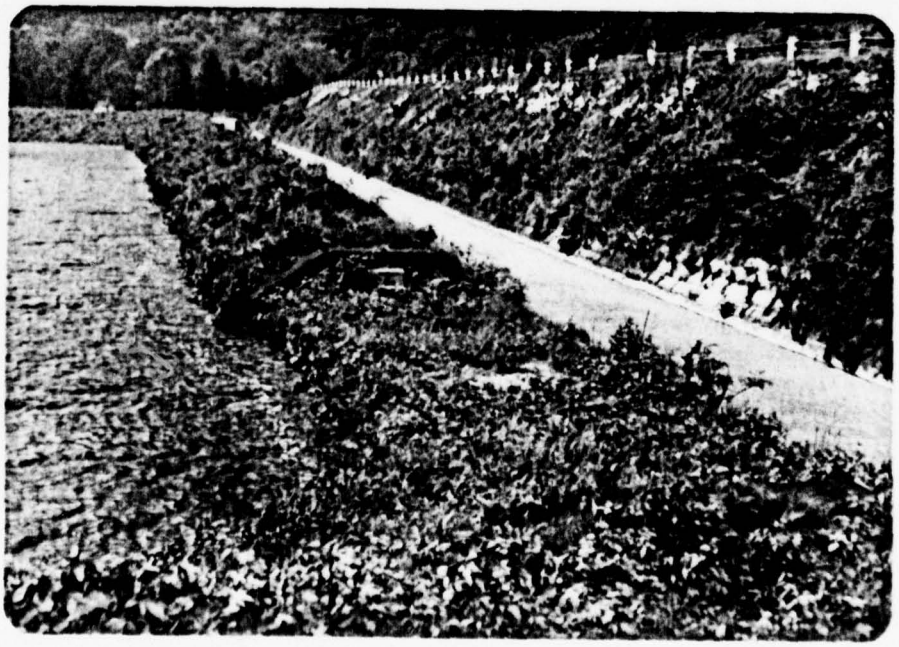
Photograph No. 4

Primary spillway chute.



Photograph No. 5

Crest of primary spillway.



Photograph No. 6

Emergency spillway and diversion channel.

Photograph No. 7

Valve house.

Photograph No. 8

Blow-off pipe (four 4-inch-diameter and two 8-inch-diameter pipes).

Photograph No. 9

Blow-off pipes discharging.

Photograph No. 10

Downstream: Lower Dam.

APPENDIX D
CALCULATIONS

DAMPODONIA
CONSULTING ENGINEERS, INC

By LTC Date 8-21-78 Subject UPPER KITTANNING DAM Sheet No. 1 of 1
Chkd. By BE Date 9-11-78 WATERSHED & LAKE AREA Proj. No 78-114-22

A) WATERSHED AREA (USGS ALTOONA, HOLLIDAYSBURG, CRESSON ASHVILLE QUADRANGLE, 7.5 MIN SCALE)

WATERSHED AREA FOR LAKE

$= 0.6\ IN^2 \times (2000\ FT/IN)^2 \times \left(\frac{1}{5280}\ MILE/FT\right)^2$

$= 0.086$ SQ MILE

WATERSHED AREA FOR DIVERSION CHANNEL

$= (200 - 134.0)\ IN^2 \times \left(\frac{2000}{5280}\ MILE/IN\right)^2$

$= 9.47$ SQ MILE

FOR FLOOD EXCEED DIVERSION CHANNEL CAPACITY, THE WATERSHED FOR DAM WILL CHANGE FROM 0.086 SQ MILE TO 9.56 SQ. MILE

Say 9.6 SQ MILE

B) LAKE AREA (EL 1496)

LAKE AREA (1496) $= 0.12\ IN^2 \times (2000)^2 \times \frac{1}{43560}$

$= 11.0$ ACRES

Say 11 ACRE

@ EL 1500 $= 0.16\ IN^2 \times 2000^2 \times \frac{1}{43560}$

$= 14.7$ ACRES

C) SURCHARGE STORAGE

ΔH (TO DAM CREST) $= 5.5'$

$\Delta V = \frac{\Delta H}{3}(11 + 14.7 + \sqrt{147 \times 11}) = 12.81 \times \Delta H$

$= 70.4$ acre-ft

Say 70 ac-ft

DAM UPPER KITTANNING DAM

WATERSHED AREA $A_1 = 009$ SQ MILE FOR LAKE

$A_2 = 9.47$ SQ MILE FOR DIVERSION

$\Sigma A = A_1 + A_2 = 9.6$ SQ MILE

ACCORDING TO THE CHARTS PROVIDED BY COE BALTIMORE DIST. FOR SUSQUEHANNA – (REGION 1) BASIN

PMF MAX PEAK DISCHARGE = 2400 cfs/SQ MI
= 23040 cfs

Say 23000 cfs

TOTAL RUNOFF OF 26" $V_1 = \frac{26}{12} \times 9.6 \times 640$
$= 1331.2$ ac-ft

Say 13300 ac-ft

SURCHARGE STORAGE VOL AVAIL ABOVE NORMAL POOL
$V_s = 70$ ac-ft

TOTAL DISCHARGE CAPACITY OF SPILLWAYS (See P3 & 4 For plan & Section.)

PRIMARY SPILLWAY
TYPE : OGEE - LIKE OVERFLOW WEIR
$L = 34'$ $\Delta H = 4.5'$ (MAX.)
$Q_s = CLH^{1.5}$
$= (3.2)(34)(4.5)^{1.5} = 1039$ cfs say 1040 cfs

EMERGENCY SPILLWAY (DISCHARGE INTO DIVERSION)

TYPE: BROAD CREST OVERFLOW WEIR
L = 50
ΔH = 2.8' (FIELD MEASUREMENT)

$Q_6 = (2.6)(50)(2.8)^{1.5}$

$= 609$ cfs Say 610 cfs

TOTAL DISCHARGE CAPACITY = 1040 + 610

= 1650 cfs

MOST OF THIS WATER IS INFLOW FROM "DIVERSION CHANNEL OVERFLOW SPILLWAY" AT UPSTREAM END

TYPE BROAD CREST OVERFLOW WEIR
L = 98

$Q_3 = (2.6)(98)(H)^{1.5} = 1650$ cfs

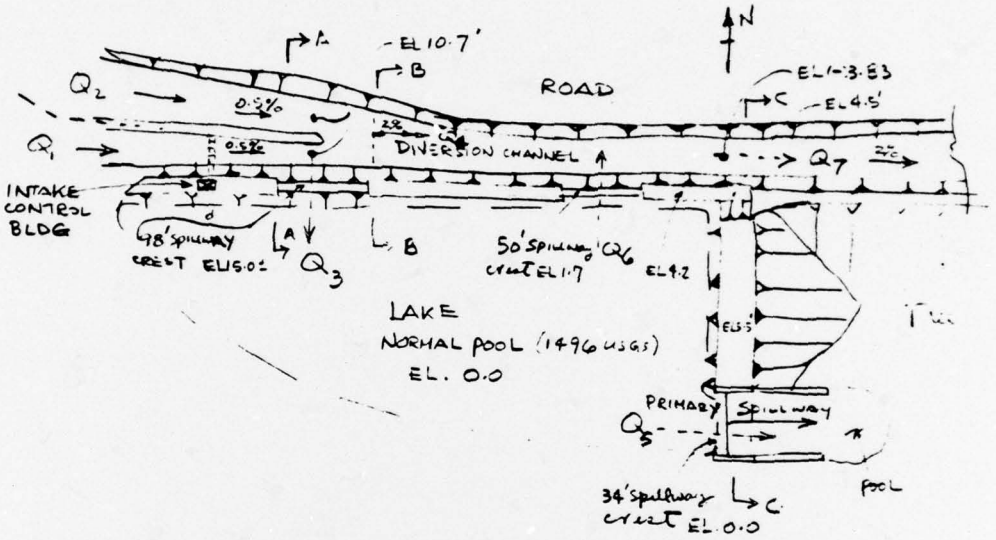
$H = 3.47'$

THE CREST IS 4'-4" ABOVE BOTTOM OF CHANNEL
THEREFORE, THE WATER DEPTH @ CHANNEL IS

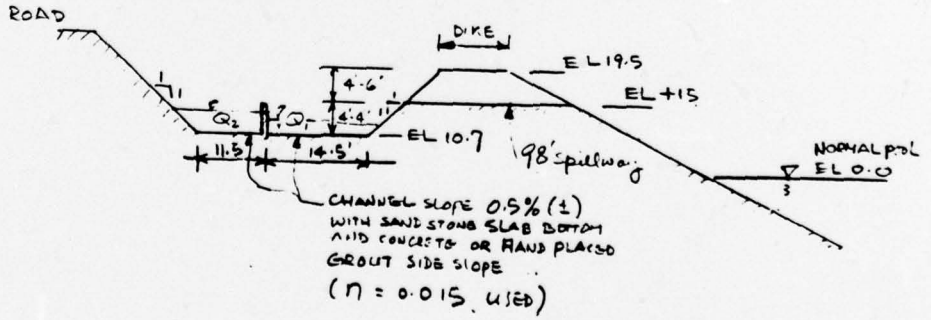
4'-4" + 3.47' = 7.8 FT (WATER IN DIVERSION)

CALCULATE CHANNEL FLOW AS FOLLOWS

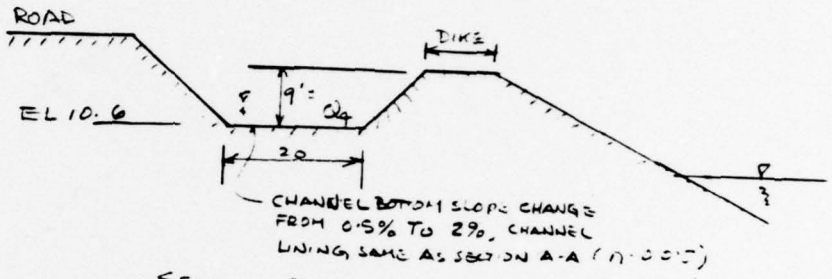
CHANNEL FLOW CAPACITY



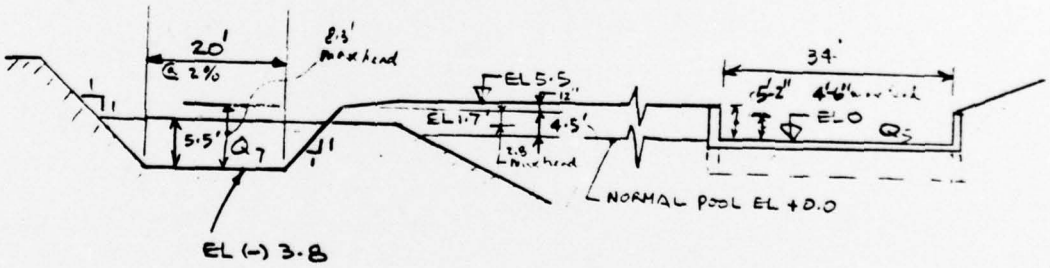
SKETCH OF UPPER KITTANNING RESERVOIR
HYDRAULIC FEATURES



SECTION A-A



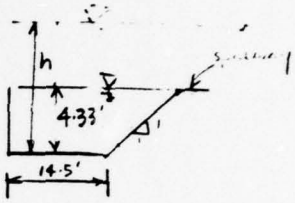
SECTION B-B



SECTION C-C

DETERMINE FLOW RATE, WATER DEPTH & CRITICAL DEPTH.

A) Q_1 (SECTION A-A)



A = AREA = $\left(\frac{14.5+18.8}{2}\right)(4.3) = 72.2$ SQ.FT

T = TOPWIDTH = $14.5 + 4.3 = 18.8$ FT

P = WET PERIMETER = $4.3 + 14.5 + \sqrt{2}\,4.3 = 25.0$ FT

$R = \frac{A}{P} = 2.9$

CRITICAL Q_c

$$\frac{Q_c^2}{g} = \frac{A^3}{T}$$

$$Q_c = \sqrt{\frac{(72.2)^3 \times 32.2}{18.8}} = 802 \text{ cfs}$$

$$V_c = \frac{802}{72.2} = 11.1 \text{ fps}$$

NORMAL FLOW

$$Q_n = \frac{1.486}{n} A R^{2/3} S^{1/2}$$

$$= \frac{1.486}{0.015} (72.2)(2.9)^{2/3} (0.005)^{1/2}$$

$= 1026$ cfs > 802 cfs SUPERCRITICAL FLOW

$V_n = 14.2$ fps

Say $(Q_1)_{max} = 1025$ cfs ; $V_1 = 14.2$ fps

Back figure d_c (approximately)

$$A = \left(14.5 + \frac{d_c}{2}\right) d_c$$

$$T = (14.5 + d_c)$$

$$\frac{(1025)^2}{32.2} = \frac{\left[14.5 d_c + 0.5 d_c^2\right]^3}{14.5 + d_c}$$

$$d_c \cong 5.056'$$

say 5.1' > 4.3' Supper critical.

FOR WATER DEPTH OVER "spillway" CREST

$$A = \left(14.5 + \frac{h}{2}\right) h$$

$$P = 14.5 + h + \sqrt{2}\, h = 14.5 + 2.414 h$$

$$R = \frac{A}{P}$$

$$Q = \frac{1.486}{0.015} (0.005)^{1/2} A R^{2/3} = 7.005 A R^{2/3}$$

h ft	A ft²	R ft	Q cfs	V fps
4.5	75.4	2.97	1091	14.48
5.0	85.0	3.20	1293	15.2
5.5	94.9	3.42	1507	15.9
6.0	105.0	3.62	1735	16.5
6.5	115.4	3.82	1975	17.1
7.0	126.0	4.01	2229	17.7
7.5	136.9	4.20	2495	18.2
8.0	148.0	4.38	2774	18.7

h ft	A ft²	R ft	Q cfs	V fps
8.5	159	4.6	3066	19.2
9.0	171	4.7	3370	19.7

B) Q_2 (Section A-A)

$$A = (11.5 + \frac{h}{2})h$$

$$P = (11.5 + h + \sqrt{2}\,h) = 11.5 + 2.414h$$

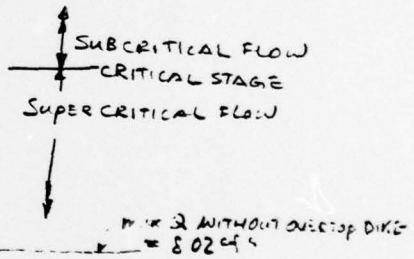
$$R = \frac{A}{P}$$

$$Q = \frac{1.486}{0.015}(0.005)^{1/2} AR^{2/3} = 7.005\, AR^{2/3}$$

CRITICAL Depth, d_c FROM

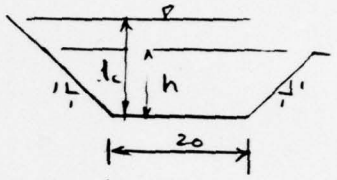
$$\frac{Q^2}{32.2} = \frac{\left[(11.5 + \frac{d_c}{2})d_c\right]^3}{11.5 + d_c}$$

h	A	R	V	Q	d_c
FT	FT^2	FT	fps	cfs	ft
0.335	3.91	0.318	3.26	127	0.335
1.0	12.0	086	6.4	76	1.10
2.0	25.0	1.53	9.3	233	2.26
3.0	39.0	2.08	11.4	445	3.42
4.0	54.0	2.55	13.1	706	4.57
4.5	61.9	2.77	13.8	854	5.14
5.0	70.0	2.97	14.5	1013	5.71
5.5	78.4	3.2	15.1	1183	6.27
6.0	87.0	3.35	15.7	1364	6.84
6.5	95.9	3.53	16.2	1556	7.40
7.0	105.0	3.70	16.8	1759	7.96
7.5	114.4	3.86	17.3	1973	8.52
8.0	124.0	4.02	17.7	2198	9.08
8.5	133.9	4.18	18.2	2434	9.64
9.0	144.0	4.33	18.6	2682	10.20
9.5	154.3	4.48	19.1	2940	10.76
10.0	165.0	4.63	19.5	3211	11.31



c) Q_4 & Q_7 (Section B-E) (Section C-C)

$A = (20 + h)h$
$T = 20 + 2h$
$P = 20 + 2\sqrt{2}\,h = 20 + 2.83h$



$R = \frac{A}{P}$

$Q = \frac{1.486}{0.015}(0.02)^{1/2} AR^{2/3} = 14.01\,AR^{2/3}$

CRITICAL depth d_c, FROM

$$\frac{Q^2}{32.2} = \frac{[(20 + d_c)d_c]^3}{20 + 2d_c}$$

normal h ft	A ft^2	R ft	V fps	Q cfs	critical d_c ft	
0						
0.5	10.25	0.48	8.6	88	0.84	
1.0	21	0.92	13.3	278	1.77	
2.0	44	1.71	20.1	883	3.69	
3.0	69	2.42	25.3	1743	5.60	
4.0	96	3.07	29.6	2838	7.50	
5.0	125	3.66	33.3	4160	9.37	
6.0	156	4.22	36.6	5707	11.22	
7.0	189	4.75	39.6	7481	13.05	
8.0	224	5.25	42.4	9486	14.86	
8.3	235	5.4	43.1	10123	15.40	— max for Q_7

BASED ON THE ABOVE (P. 3 to P. 8) CALCULATIONS, IT IS ESTIMATED THAT

@ d_n (NORMAL) = 7.81 FT @ Sect A-A

$Q_1 = 2670$ cfs $\Rightarrow V = 18.6$ fps

$Q_2 = 2110$ cfs $\Rightarrow V = 17.5$ fps

and $h = 3.47'$

$Q_3 = 1650$ cfs

UPSTREAM FROM THIS POINT THE MAX INFLOW WILL BE $Q_1 + Q_2 + Q_3 = 2670 + 2110 + 1650 = 6430$ cfs

✓ CHECK DOWNSTREAM CHANNEL DEPTHS

@ SECTION B-B (7% channel)

$d_n = 5.4$ ft $< 9'$ as provided OK

$Q_4 = 4780$ cfs $\simeq Q_1 + Q_2 = 4780$ cfs

O.K Q_3 CONTROL

@ Section C-C (2% channel)

$Q_7 = 4780 + 610$ (FROM SPILLWAY)

$= 5390$ cfs

$d_n \simeq 6$ ft $< 8.3'$ as provided OK

OK Q_3 CONTROL

TOTAL DISCHARGE @ SECTION C-C

$$Q_7 + Q_5 = 5390 + 1040$$
$$= 6430 \text{ cfs}$$

WHICH IS EQUAL TO TOTAL INFLOW $Q_1 + Q_2 + Q_3 = 6430$ cfs

THIS INFLOW REPRESENTS THE MAXIMUM INFLOW THAT COULD BE CARRIED BY CHANNELS & SPILLWAYS WITHOUT OVERTOPPING THE DAM. ANY ADDITIONAL FLOW WILL CAUSE THE INCREASE OF Q_1, Q_2, and Q_3. THE INCREASED Q_1 & Q_2 CAN BE HANDLED BY DIVERSION CHANNEL UP TO 10,000 cfs @ SEC. C-C, HOWEVER THE INCREASE OF Q_3 WOULD RISE THE LAKE LEVEL ABOVE THE "LOWER PORTION" OF DAM. THEREFORE

$$Q_3 = 6430 \text{ cfs} \quad (\text{max.})$$

APPROXIMATE PERCENT OF PMF WITHOUT OVERTOPPING

$$= \left(\frac{6430}{23000} + \frac{70}{13300}\right) 100\% = 28.4\%$$

Say 28% PMF

APPENDIX E
REGIONAL GEOLOGY

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REGIONAL GEOLOGY

The Upper Kittanning Dam and Reservoir are situated on rock of the Lower to Middle Pocono Formation (Mississippian Age). The rock strata consist primarily of medium thick (six inches to two feet) red sandstone. These strata are overlain by red sandstone interbedded with red shale and claystone. The strata strike approximately N30E, with dips ranging from 15 to 20 degrees to the northwest. The rock is resistant to weathering and forms moderately steep, stable slopes.